COMBAT RATION NETWORK

FOR

TECHNOLOGY IMPLEMENTATION

Universal Benchtop Package Tester

Final Technical Report STP 2002

Results and Accomplishments (Mar 03 – Sep 06)

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14. ABSTRACT

The objective was to develop a bench-top unit to test for leaks and residual gas in polymeric trays and MRE pouches. A leased unit was used tested to validate design and software changes. Hardware and software improvements reduced operational complexity. The design goal was to measure residual gas in retorted trays on average to +-10% of the destructive methods. Detection of 300 micron leaks with 80%+ effectiveness with less than 0.5% false positives was also defined and met. Samples of production trays were tested. A small outlying dataset had gas significantly below the 250cc limit. The unit was demonstrated to measure gas within -0%+20% of destruct measurements by a producer. As a QA tool, this represents an adequate means to maintain process control without excessive product waste. A scope change was requested during the final project ITR for a design goal from -0%+20% to +-5cc. It was deemed necessary to fulfill retort regulatory compliance requirements. Instead of being a QA tool as originally intended, it would be a regulatory compliance instrument. Supplemental tasks to improve system performance to the revised design goal were not successful.

15. SUBJECT TERMS

Combat rations, Quality control, residual gas, non-destructive, measurement tool, Group rations, Package integrity, Polymeric Tray packs, head space, production control, process control

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1. Results and Accomplishments

1.1. Introduction and Background

Current military unique combat ration packages meet Military Service needs by being lightweight and flexible. They provide a minimum of three years of shelf life, but this packaging is susceptible to tears and holes during the manufacturing process. To avoid package integrity problems, pouches and trays are inspected at several levels of production; by the producers, by the USDA, by the assemblers and by U.S. Veterinary Inspectors on assembled cases. These human visual inspections look for defects, but humans miss defects, in spite of the effort and costs applied.

Recognizing that the current process is inefficient and costly, the Multiple Unit Leak Detector (MULD) was introduced to detect holes, leaks, weak seals, and excessive amounts of residual gas. And it has great potential, but it was implemented before many of the in-process variations were identified and addressed. Being unable to handle variations in production, producers could not rely on the MULD enough to realize the savings potential that was anticipated. The basic MULD technology is a measurement of force decay in a vacuum, but other technologies were considered since the focus was solely residual gas measurement. An early task was to conduct a market search to evaluate competitive technologies, before proceeding with pressure decay under vacuum.

The Traypack Benchtop leak tester acquired and tested in CORANET STP#1020 was highly successful at detecting leaks in polytrays. The software delivered with the unit did not, however, include a function or interface to enter information required for estimating residual gas. Additionally, product height variation and a fixed height sensor plate and tray cavity contributed to reduced gas measuring effectiveness with some products.

A critical test for lot acceptance of polytrays is the amount of headspace in each polytray. Current lot acceptance protocols include destructive headspace measurement. Initial experimentation with the tester from STP#1020 showed a strong correlation between force exerted by residual gas under vacuum and headspace volume. In addition to the significant cost savings by the elimination of destructive tests, overall product quality could be improved if more trays were tested during production since problems could be identified sooner. If an issue is identified, the entire production run from the last test is put on hold for evaluation or rework. More frequent testing would reduce the size of a potential QA hold.

For the STP#1020 system to function correctly as leak tester or even potentially as a residual gas-measuring tool, several key settings must be manually entered. The pressure plate heights for the chamber require custom-machined spacers for ranges of product heights. Incorrectly adjusted plates lead to a significant reduction in gas measurement accuracy. With the current software detection algorithm, only leaks are detected. A separate data file must be opened to access force measurements. Calculation of system detection settings for leak detection or residual gas for new and varying products is a manual process and requires a dedicated, highly skilled/engineer labor resource. Consistent results require the availability and commitment of highly skilled resources.

Significant savings in product cost, especially with polymeric trays, may be realized by elimination of all destructive tests. In process control, i.e. monitoring and maintaining control of the key production variables fill weight and vacuum during sealing, can provide better quality control that reliance on post-production auditing. In tandem with in-process control measures, non-destructive testing would improve overall product quality if more trays are tested during production without the penalty of waste, allowing problems to be identified sooner. A single cavity off-line tester for polymeric trays was envisioned, with the capability to potentially test pouches. A non-destructive test to measure container integrity (internal pressure test) was not part of this requirement, but could possibly be added later if the technology is compatible.

1.2. Objectives

This project was to develop a multi-purpose bench-top test unit that can test for leaks and for residual gas in both polymeric trays as well as MRE pouches.

1.3. Results and Conclusions

A unit was leased and tested to validate design changes and software improvements. Hardware and software system improvements were incorporated to reduce operational complexity. The unit was designed to be user friendly and accurate. The original design goal to measure residual gas in a retorted tray on average to within +-10% of the subsequent destructive measurement was met. Trays typically contain 100 to 250cc of residual gas. Industry and government stakeholders agreed that as a QA tool, +-10cc for 100cc headspace to +-25cc for 250cc headspace would be sufficient. Additionally, it detected 300 micron leaks with greater than 80% effectiveness with less than 0.5% overall false positives.

A significant sample of different trays from production lots was tested. The validity of the force to residual gas correlation was modeled and accessed. Once a dataset was collected, results were made available to aid in the setup of additional units at producers' plants.

Observed outlying data points would not represent an operational issue since headspaces for that subset of trays were substantially below the current limit of 250cc.

A scope change was requested by a government stakeholder during the final project ITR. A design change from the successfully demonstrated +-10% (or -0%+20% as suggested by industry) to an absolute +-5cc for all trays was deemed necessary to replace existing retort regulatory compliance requirements. Instead of using the machine a QA tool, it would be an instrument for regulatory compliance. Supplemental tasks to improve the system to reach the revised design goal were not successful.

1.4. Recommendations

The unit was demonstrated to be capable of measuring residual gas within polytrays within +20%-0% for the sample group. As a QA tool, this represents an adequate means to maintain process control without excessive product waste.

Elimination of dedicated residual gas testing would have tremendous cost savings if data from retort compliance testing is applied to the gas testing requirement. If adequate data is collected for retort compliance, residual gas testing would become redundant.

2. Short Term Project Activities

2.1. Prototype Development

Rutgers subcontracted the fabrication of a Benchtop Traypack Leak tester under STP#1020. Tests were conducted on products to access performance. Additional research uncovered some weaknesses in the system design as a residual gas tester that were addressed in an advanced unit and well as enhancements to overcome shortcomings of the production MRE MULD units.

2.2. Phase I, Unit Specification & Subcontracting

2.2.1. Develop an updated specification to address all shortcomings of the prototype unit

March 2003 – Dr. John F. Coburn presented a project overview for CORANET2 Workshop #6. Jeff Canavan presented a package integrity overview at an Academic Briefing at the FMT Facility. Precision Automation provided a demo of their test unit at their facility. It incorporates many of the systems enhancements proposed in STP#1020, as well as others. Some design changes include improved noise reduction, better repeatability, and better false-reject ratios with vacuum decay

compensation. The chamber cannot accommodate a traypack without modification. Tests were not done on trays.
April 2003 - Literature search was completed. For non-destructive residual gas testing, pressure differential force measurement and vacuum differential represent the best candidates. Application of a squeeze test may prove effective for other package integrity tests, but no commercial integrator has brought a unit to market. The prototype developed at the Rutgers Industrial Engineering was demonstrated and potential design integration issues were discussed and noted. STP#1020 data was reviewed. Work with design specifications continued.

2.2.2. Solicit proposals from integrators

March 2003 - Precision Automation, PTI-USA, and iTi-Qualitek were contacted to provide information on recent enhancements to their non-destructive leak detection systems and experience with residual gas analysis. Custom fabrication of tooling is required to test trays in different test fixtures. Costs associated to do this work were not included in the original budget. Literature search was completed. For non-destructive residual gas testing, pressure differential force measurement and vacuum differential represent the two most likely candidates. Application of a squeeze test may prove effective, but no commercial integrator has brought a unit to market. Alternative package integrity and seal inspection systems, such as airborne ultrasound and laser reflection, while effective at quantifying seal characteristics, cannot provide a measurement of container contents.
April 2003 - Precision Automation and PTI-USA expressed interest in manufacturing systems to meet the objectives of the project. Each has expressed a need for funding modifications of their testers to accommodate the polymeric traypacks. Modification estimates ranged from $700-$1500 with lead times 4-8 weeks. iTi-Qualitek has not yet provided any additional information about their interest in participating in this project.
Equipment suppliers have been slow in providing modification quotations. Units cannot be evaluated with sample trays without a suitable cavity insert. Delays in quotations and longer than expected modification lead times will cause the entire project to slip about 4 weeks.
Tray schematics and/or tray samples were provided to PTI-USA and Precision Automation. Once fixtures are ordered and completed, a visit will be scheduled to test each unit at the integrators with a significant sample set of traypack items to verify the repeatability and applicability of the technologies. Work will continue on design specification based on the results of the tests.
May 2003 - Precision Automation was issued a purchase order to modify their testing chamber. The work is scheduled to be completed by mid-June. PTI-USA provided a quote for the fabrication of a cavity insert for the traypack. The price quote exceeded $6500. PTI-USA has provided schematics for the insert. With the consent of PTI-USA, the plans will be used to fabricate an insert in the Rutgers University Industrial Engineering machine shop. The total cost will not exceed $1500. Work is scheduled to begin by mid-June and will be completed by August. iTi-Qualitek has not yet expressed interest in participating in this project.
Precision Automation visited the Demo Site to discuss cavity design and functionality issues. Sample trays were provided.
June 2003 - Precision Automation completed the testing chamber modifications as scheduled. Polytrays filled with Creamed Ground Beef, Pork Sausage in Brine, and Turkey Slices were tested on the unit to determine repeatability and correlation using regression analysis. Regression correlations for the data collected for beef, pork, and turkey were 0.950, 0.916, and 0.987 respectively. Correlations for comparable data collected with the iTi-Qualitek leak tester in STP#1020 were similar for beef and pork. However, iTi-Qualitek data correlation for turkey was less than 0.60.
July 2003 – Work to fabricate a cavity for the PTI-USA tester at the Industrial Engineering Dept. continued. The bottom part of the cavity was completed. Work on the top plate will be completed in early August.
ITi-Qualitek has been integrated with Uson L.P., and is now located in Houston, Texas. Issues regarding the shortcomings of the previous iTi-Qualitek unit were discussed. They have expressed interest in visiting the FMT Facility to discuss further design details in August.

August 2003 - Both the top and bottom of the insert for the PTI-USA unit are completed. A preliminary evaluation at PTI-USA is scheduled for September. Additional testing will be scheduled once PTI has approved the performance of the insert. Meeting at PTI-USA in Tuckahoe, NY, to review plans and demonstrate tester.

ITi-Qualitek has been integrated with Uson L.P., and is now located in Houston, Texas. A representative of Prex, a division of Uson L.P., requested information to develop a quotation for a tester. If the tester design specifications fit the technical requirements of automatic set up and new product learning mode, a trip will be scheduled to evaluate a tester.

September 2003 - With the consent of PTI, the cavity was fabricated by Rutgers University IE machine shop using PTI schematics in August. The insert was sent to PTI for integration. PTI reported chamber leaks which would reduce accuracy. A trip was made to resolve the issue. The leaks were located and sealed. The performance evaluation of the test chamber conducted by PTI indicated an acceptable leak rate of less than 5cc/min at the test vacuum level. At PTI's request, a sample set of 20 trays were filled with controlled volumes of water and sealed with no vacuum at the FMT Facility using the Raque tray sealer. All trays would contain approximately equal total volumes of water and headspace. Reducing the fill volume increased the headspace directly. PTI set up the test parameters and conducted the tests while Rutgers recorded the results. After the testing was completed, the trays' headspace was measured destructively. Multiple R regression correlation for the measured head space vs. the test measurement for the trays was 0.95. The mean deviation of calculated to measured headspace was 13.5%.

Precision Automation's tester provided substantially better results. While the regression correlations were comparable for the different test products, the mean deviations of calculated to measured headspace were only 1.4%, 1.2%, 0.6% for turkey slices, pork sausage, and creamed ground beef, respectively. No calculated gas estimate deviated more than 10% from the destructively measured headspace.

A representative of Prex, a division of Uson L.P., sent a quotation for a custom tester. Another representative has scheduled to visit the FMT Facility to review the project needs. If a unit can be prepared for testing by next month, the Prex unit will be evaluated.

October 2003 - iTi-Qualitek has been integrated with Uson L.P., and is now located in Houston, Texas. A representative of Prex, a division of Uson L.P., submitted a quotation for a custom tester. A representative from Uson visited the FMT Facility this month to review the project needs. A Uson test unit was supposed to be available by the end of October for evaluation. No confirmation of the completion was received by the end the month. The ITR will be scheduled for the CORANET workshop in December. Uson's unit will be included in the evaluations if it's made available before the end of November.

November 2003 - The Uson unit was available for testing by the last week of November in Houston. 12 trays were brought and 160 tests were conducted. Uson data analysis will be complete by the next CORANET workshop. PTI-USA and Precision Automation testing and analysis are complete.

2.2.3. Producer Survey

October 2003 - Consulted with producer and determined available technical resources would be minimal. No training past basic machine procedure and operation would be required. Manual inspection labor was not shared by the producer. Labor estimates were deemed acceptable at the following CORANET workshop.

2.2.4. Evaluate technologies, proposals and subcontract integrator

December 2003 – Project progress was reported at CORANET Workshop#8 in the New Brunswick, NJ area. Uson data analysis proved inconclusive. Minute changes in plate height caused dramatic changes in force measurements that were neither linear nor predictable. An alternative method of force to gas volume using Boyles gas law, PxVx=PyVy will be explored at Precision Automation when their unit returns to Cherry Hill, NJ. Initial testing and data analyses for PTI-USA, Precision Automation, and Prex-Uson units are complete. A re-evaluation of an alternative testing method is will be conducted before the ITR.

2.3. Phase II – Fabrication & Sample delivery

2.3.1. Unit prototyping, fabrication, software validation, reporting

January 2004 - A trip was made to Precision Automation in Cherry Hill, NJ, January 29 & 30 to conduct experiments and collect data using an alternative method of force to gas volume using Boyles gas law, PxVx=PyVy. Analysis of the data and project extension recommendation will be made by the end of February. Re-evaluation of an alternative test procedure has extended project schedule. The recommendation to continue this project will be based on the analysis of the alternative procedure.

February 2004 – The alternative method using PxVx=PyVy was tested at Precision Automation in Cherry Hill on February 10. Gas was predicted with a range of –9.8% to +7.0%, with a mean deviation of 3.9%. The plate available was smaller than the tray flange. A larger plate should provide better results. Based on the experimental data from eight samples, it is recommended that the project be extended to include a larger sample size with different traypack varieties. A new plate will be made and used to test the larger sample group.

March 2004 - A sample set of different polytray products was requested from producers. Trays should be available in May for testing. Design plans for a larger force plate were provided to the Rutgers Industrial Engineering Dept. A plate was completed and fitted into the unit. After the load cell was re-tared for the new plate, data collected from FMTF trays correlated better to model predictions. Results are consistent and repeatable, however, the current model (MAR04) still relies on correction factors. Correction factors should be tested with additional products to determine validity. Testing has been hampered by the delay of commercial products. Applying a universal test method is more complicated then initially anticipated. Additional modeling has extended the project. An extension was approved until May 3, 2004 to fabricate a larger plate, validate the method on a sampling of producer-made trays, and hold an ITR to report the revised model testing results.

April 2004 – A remote teleconference ITR was held April 29. A sample set of four different polytray products was delivered from a producer. Experimental data from the trays was consistent and repeatable. The MAR04 model correction factor did not correlate to destructive measurements and was not valid. A significant change was made to the model to factor out the change in force plate contact area during the test cycle. No correction factor is required when the force plate area is factored out. The dynamic model produced result with +-5% of destructive measurements for the limited set of test samples.

The project was extended until August 4, 2004. Validation of the dynamic model with producer polytrays will continue along with retorted FMTF samples. Testing will conclude when additional producer trays are tested in June. Should experiments provide evidence of universal applicability of the model, software will be written to automate the procedure in the bench-scale tester at Precision Automation. A hands-on workshop will be held at the FMT Facility when a prototype unit is completed.

May 2004 – ITR was held at the FMT Facility. (See appendix) Testing of retorted water-filled and producer supplied trays continued. Experimental data from the trays remains consistent and repeatable. The contact area vs. force model correlates to destructive measurements to within +-5% of the destructive.

June 2004 - Testing of retorted water-filled trays continued. Data from additional trays remains consistent and repeatable. The contact area vs. force model correlates to destructive measurements. The procedure produces results within +-5% of the destructive measurements for the products tested. Applying a universal test method has become more complicated than initially anticipated. Additional experiments and modeling have extended the project schedule. Software and hardware development tasks originally outlined for Phase II will be carried out in Phase I pending successful testing of additional producer items and approval.

July 2004 – Precision Automation visited the FMT Facility to discuss automation software proposal. The original project proposal includes tasks through Phase IV. Remaining funding is adequate for completion of a prototype and workshop. Additional funding will be requested for the continuation of the project tasks outlined in for Phase III and Phase IV. Precision will be contracted to write software to automate the procedure in their bench-scale tester. A hands-on workshop will be held at the FMT Facility when a prototype unit is completed. Estimated time to complete programming and debug is 8-12 weeks once work begins.

August 2004 - Precision Automation visited the FMT Facility twice to discuss automation software proposal. The procedure has been defined and Precision Automation will begin programming when a contract is approved. An extension request was approved until December 4, 2004.

September 2004 – Precision Automation visited the FMT Facility to discuss automation software proposal. A purchase ordered has been issued for the software development. The procedure has been defined and Precision Automation has begun programming.

October 2004 – Project progress was presented at CORANET Workshop in Myrtle Beach, SC. Precision Automation was unable to provide the necessary resources to complete the software task as scheduled. It is anticipated that additional resources will become available to complete the job by mid-December. A three-month extension will be requested to complete this project. Unbudgeted administrative costs have been applied to this STP in response to a change in cost recovery. Since the prototype will be completed no earlier than mid December, there will not be sufficient funding for troubleshooting, testing, and a workshop. Additional funding will be requested to continue the project. The software module should be completed by mid December. A hands-on workshop will be scheduled at the FMT Facility when a prototype unit is completed. The workshop should take place in February.

November 2004 - The project has been extended until March 15, 2005. Meeting with Precision Automation to review data collected on iTi-Qualitek unit at FMT Facility and software functionality requirements. The experimental results obtained from the iTi-Qualitek unit at the FMT Facility indicate the simplified testing procedure and more complicated mathematics produce acceptable results. The final algorithm is substantially more complex than the original formulas. The nature of the work required for programming Precision Automation's unit is very specific. Any changes that might be needed after the program is compiled would require significant effort. After analyzing the formulas and reviewing the method, the project director at Precision Automation has strongly recommended that some additional data be collected to fine-tune the model for their specific configuration. Details relating to the response of their load sensor and data acquisition boards may change the results. A small series of verification tests would reduce the risk of a costly software rewrite. The testing is scheduled for December with on-hand trays supplied by Wornick. Any changes will be incorporated into the method and handed off to the programmer in the first week of January. Coding will require 6 weeks. The unit will be tested in Cherry Hill before being trucked to the FMT Facility in mid February. The hands-on demonstration is scheduled for late February. Based on the proposed project changes, budget changes are requested. Over the course of the project, substantially less has been expended for subcontracting, equipment maintenance and upgrading. However, additional labor has been invested in the development and testing of new procedures and models.

December 2004 - Meetings with Precision Automation to review data collected on the Precision Automation testing unit in Cherry Hill, NJ. The experimental results obtained from the iTi-Qualitek unit at the FMT Facility indicated that the simplified testing procedure and more complicated mathematics produce acceptable results. The final algorithm is substantially more complex than the original formulas. Results from the verification runs show that equal force model points provide better readings than equal force slope points.

No changes in the algorithm are necessary. Programming will commence in January. Coding should be completed in 6 weeks. The unit will be tested in Cherry Hill before being trucked to the FMT Facility in mid February. The hands-on demonstration is scheduled for late February. Programming progress will be monitored and a test of the software will be scheduled for late January. The software module should be validated by mid February. A hands-on workshop will be scheduled as soon as practical for late February at the FMT Facility.

January 2005 - Experiments run at Precision Automation to collect data. Meeting to review and discuss results. Programming of the interface has not been on schedule. Several issues remain with calculating variables dynamically. Programming the interface has proved more challenging that originally anticipated. Availability of resources has also hampered progress at Precision Automation. While no changes were made in the algorithm, automating the calculation of key variables is causing some unforeseeable delays. Scheduling of the demonstration is being delayed due to technical and resource allocation problems. The unit should be ready to demonstration no later than late March. Programming progress will be monitored and a test of the software will be scheduled for mid-February. The hands-on workshop will be scheduled as soon as practical for late March at the FMT Facility.

February 2005 - Experiments run at Precision Automation to collect data. Meeting to review and discuss results. Programming of the interface has not been on schedule. Some minor issues remain with variable calculations. Data collected from experiments has been not as accurate as previous testing. Data analysis shows that testing trays under increased vacuum should provide more accurate results. The stock sensor is only designed to measure force up to 50 kg. Extrapolating force values up to an absolute vacuum yield forces exceeding 200kg. It is recommended that another force sensor capable of measuring 200kg be identified and installed. Accuracy is currently within +-15% of destructive measurements. Increasing the vacuum should provide accuracy approaching +-5%. Scheduling of the demonstration is being delayed due to technical and resource allocation problems. A no-cost extension until April 15, 2005 is being requested.

March 2005 - The project has been extended until April 14, 2005. Experiments run at Precision Automation to collect data. Meeting to review and discuss results. Module programming is complete. Issues remain with variable calculations. Another force sensor was identified, ordered, and installed. Experiments run under increased vacuum shows results +-10% of destructive measurements for unretorted water trays. The current procedure requires determination of initial shim height for maximum accuracy. Additional fine tuning should eliminate the need for any preliminary testing. The initial test of a product filled tray yields a slightly different result than all tests that follow. It is probable that entrapped gas produces slightly different expansion characteristics than headspace gas. The anomaly is probably due to gas being drawn out of the product during the first vacuum cycle. The hands-on workshop will be scheduled as soon as practical at the FMT Facility.

April 2005 - The project has been extended until May 31, 2005. Experiments run at Precision Automation to collect data. Meeting to review and discuss results. Module programming and integration is complete. Minor issues with variable calculations remain. The current procedure requires determination of initial shim height for maximum accuracy. The model has problems if the chamber is not sealed correctly at the beginning of the test cycle. Additional fine-tuning of the automated algorithm will eliminate systematic error caused by testing delays. If the IPR produces positive feedback, a follow-on extension with additional funding will be requested for monitoring results and supporting the unit at a producer's plant. The hands-on demonstration / IPR for STP#2002 has been scheduled to coincide with the IPR for STP#2016 at the Demo Site in early May to save travel costs and increase participation.

2.3.2. NCIC questionnaire, preparation, distribution, and analysis

Traditional cost/benefit analysis was sufficient to justify the research effort expended by this project. Analysis of non-traditional value was deemed redundant. Cost avoidance by reducing or eliminating mandated destructive testing for end item residual gas testing would payback the unit acquisition cost within 2 years.

2.3.3. Contact suppliers to get sample products / take delivery

May 2005 – Precision Automation delivered tester to the FMT Facility. IPR at the FMT Facility on May 6. Attendance: Jesse Burns, Sue Bonanno, Bob Trottier, Jeff Cleek, Dan Bittner, Brian Popelsky, Jeff Canavan, Rieks Bruins, Tom Blyskal, Basily Basily. (See appendix) The initial test of a product filled tray yields a slightly different result than all tests that follow. It is probable that entrapped gas produces slightly different expansion characteristics than headspace gas. The anomaly is probably due to gas being drawn out of the product during the first vacuum cycle. The model has problems if the chamber is not sealed correctly at the beginning of the test cycle. Additional fine-tuning of the automated algorithm will eliminate systematic error caused by testing delays. The temporary PVC chamber liner has begun to delaminate. Additional funding was requested to continue the project. Linking the data collection start time to a specific vacuum set point instead of time improved accuracy by 5%.

A follow-on extension will be requested for building a metal chamber insert, modifying the calculation application, and for monitoring results and supporting the unit at a producer's plant during the proposed validation protocol.

2.4. Phase III – Product Testing & Documentation

2.4.1. Product testing, documentation, and analysis

June 2005 - Additional funding and a project extension were requested. The project has been extended until November 30, 2005. CORANET workshop in Natick, MA, June 28 & 29. Programming work to be done by Precision Automation cannot begin until additional funding is approved. Fabrication of a replacement chamber liner cannot begin until funding is approved. A follow-on extension was requested and approved to build a metal chamber insert, modify the calculation application, and to monitor results and support the unit at a producer's plant during a validation protocol.
July 2005 - Additional funding and a project extension were requested and approved. The project has been extended until November 30, 2005. Meetings with Precision Automation to review programming changes. Trips to Industrial Engineering to review chamber design and fabrication.
August 2005 - Meetings with Precision Automation to review programming changes. Trips to Industrial Engineering to review chamber design and fabrication.
Programming changes and chamber fabrication have been completed. 50% of past and continuing rental costs will be credited to the purchase of the tester at the end of the validation protocol.
September 2005 -Trip to Wornick Plant in Cincinnati, Ohio by rented van to deliver test unit, conduct user training, and initiate data transfer protocol.
Eight people were trained to use the tester during the visit. A series of 10 trays were tested and yielded results similar to past experiments. The greatest differential in measured gas to predicted gas was -12%. The manual method of gas measurement is highly user dependent. The in-plant testing protocol should be consistent for results to have any validity. Unit was delivered, set up, and successfully tested at a producer's plant. Operators were trained in use and basic troubleshooting procedures.
October 2005 - Work on the validation protocol has begun, but progress is slower than expected. Since traypacks are not being produced, support of the protocol requires resources dedicated to the project objectives. Pouch production requirements at the Wornick plant have reduced resources available to devote to the validation protocol. Every month of project slippage results in increased project expenses accumulating for machine rental and administrative costs.
An extension will be requested to continue the project.
November 2005 - A project extension was requested. The project is scheduled to end November 30, 2005. A project review was presented during the CORANET Workshop in San Francisco, CA, November 16-17. Contact with industrial partner to collect protocol data. Work on the validation protocol has begun, but progress continues to be slow. Pouch production has reduced available resources.
December 2005 - A project extension was approved. The project was extended to May 31, 2006. Contact with industrial partner to collect protocol data.
The following data was released by the partner on December 16. The specific tray content and lot number were
removed.

Automated Vs. Manual Residual Air Testing Results

Sample	Automated (Rutgers Machine)	Manual (Displacement)	Difference		
	Retorted, placeable in sauce				
1	367	360	1.9%		
2	246	240	2.5%		
3	348	340	2.4%		
4	243	240	1.3%		
5	278	280	-0.7%		
6	326	300	8.7%		
7	280	280	0.0%		
8	260	260	0.0%		
	Automated (Rutgers Machine)	Manual (Displacement)		AVG	2.0%
Sample	Hot filled, pumpable				
1	252	240	5.0%		
2	194	200	-3.0%		
3	163	180	-9.4%		
4	235	200	17.5%		
5	184	180	2.2%		
6	175	160	9.4%		
7	200	190	5.3%		
8	183	170	7.6%		
				AVG	4.3%

January 2006 - Contact with industrial partner to collect protocol data. No production was scheduled in January and no additional data was released.
Work on support material for the FTR was begun. An incremental funding increase will be required to cover additional expenses associated with the extended lease and accumulating expenses.
February 2006 - Contact with industrial partner to collect protocol data. No production was scheduled in February and no additional data was released.
Work on support material for the FTR has continued. No additional data was made available.
March 2006 - Attended CORANET Workshop in Daytona Beach, FL and briefed members on STP status. Contact with industrial partner to collect protocol data. No production was scheduled in March and no additional data was released.
DSCP offered inventory to begin validation testing. Four products were requested and delivered from DDJC; Potatoes with Bacon, Beef Hash, Beef Patties, and Chicken Chow Mein. A request was made to Wornick to crate the tester and have it shipped back to the FMT Facility so testing can begin. The proposed validation protocol recommends 10 products of varying characteristics. Each product will have 25 samples tested 3 times. Weight and temperature will also be recorded before the gas is measured destructively. Validation of four products will take place using DSCP inventory at the FMT Facility instead of production samples at a producer's plant. An incremental funding increase will be required to cover additional expenses associated with the extended lease and accumulating expenses.
April 2006 - Coordinated shipment of the tester back to the FMT Facility.
Four product sample sets and the tester are at the FMT Facility. The validation protocol has begun. DSCP offered inventory to begin validation testing. Four products were requested and delivered from DDJC; Potatoes with Bacon, Beef Hash, Beef Patties, and Chicken Chow Mein. Wornick crated the tester and have it shipped back to the FMT Facility. The proposed validation protocol recommends 10 products of varying characteristics. Each product will have 25 samples tested 3 times. Weight and temperature will also be recorded before the gas is measured destructively. Testing has begun and should be concluded by mid-May. Results will be released as soon as practical. The project is scheduled to end May 31, 2006. A two-month project extension will be requested to schedule an IPR and issue results of the four products provided by DDJC.
May 2006 - ITR at FMT Facility, May 31, 2006.
ITR May 31 Attendees: Frank Bankoff DSCP, Sue Bonanno DSCP, Larry Charya DSCP, Bob Trottier Natick, Basily Basily Rutgers, Rieks Bruins Rutgers, Magdy Hefnawy SOPAKCO,

Richard Boyd USDA, Lea Mohr Wornick, Jody Weil Wornick

The IPR presentation outline
• Non-Destructive Residual Gas Testing
• Performance Data from DDJC inventory
• Plant; Unit Demonstration
• QC Lab; Destruct validation testing
• Next Steps / Discussion

The testing procedure was reviewed step by step. The importance of the pre-evacuation stabilization step was reiterated. Changes in volume of the container occur when vacuum is applied to the container for the first time. The first vacuum cycle causes tack seal around the tray edges to yield. Once tack seal yields, all further testing is consistent since the container itself no longer changes. The stabilization step applies no more than an equivalent of 14.7 psi to the inside of the tray. This force is sufficient to open tack seal around the inner edges of the tray, but not enough to cause damage to fusion seals. While not proven, increasing the vacuum and time during the stabilization step may also cause air to be drawn out of the tray contents. Air in the head space is than more easily measured during the destructive testing procedure than air trapped within the product.
The DDJC inventory tested was 25 trays of four products, 100 total, consisting of Chicken Chow Mein – Pumpable, Beef Patties in Brine – Placeable, Beef Hash – Pumpable, Potatoes with Bacon. The testing protocol was explained. Protocol development included feedback from Natick, and Wornick. Each tray was weighed and lot numbers were recorded. Trays were tested three times. Each test cycle consisted of three steps; Stabilization, Test 1 without shim, and Test 2 with shim. After non-destruct testing was complete, each tray was tapped vigorously on a counter for 60 seconds to move air pocket to the top edge. Gas was measured using the standard destructive method. (Inverted graduated cylinder in water)
Results from the testing were then reviewed. A summary spreadsheet of the direct, uncompensated measurements was presented. The discussion that followed focused on the accuracy of the direct measurements.
Machine gas measurements were typically greater than the destruct method results, except for one product. Machine measurements for Beef Patty trays were less than destruct measurements. Offsetting all results within the dataset by the lowest observed underestimation eliminated any possibility of underestimating. Simply put, adding 11cc, 49cc, 7cc, and -9cc to direct CCMein, BeefPat, BeefHash, and PotatBac measurements, respectively, for example, would get rid of any underestimation. The offset results would be as follows;

	Offset, Uncompensated		
	Avg cc Dev	Lowest Underest.	Highest Overest.
CCMein	+22cc	0cc	+39cc
BeefPat	+21cc	0cc	+32cc
BeefHash	+16cc	0cc	+27cc
PotatBac	+12cc	0cc	+21cc

The end result would be that the non-destructive tester would typically overestimate gas volume. At most, it would overestimate as little as 21cc for PotatBac, or as much as 39cc for CCMein. Accuracy can be improved by applying regression that includes destruct measurements and tray weight correlation. Once a statistically significant set of data of is collected, product regression can be calculated and applied offline. Microsoft Excel has suitable regression functions.
The results for the 4 products tested show the tester can be a useful tool to measure headspace. Regression analysis of the data shows the tester measures gas volume with R2 of 0.922, 0.809, 0.969, and 0.654 for CCMein, BeefPat, BeefHash, and PotatBac, respectively.

	Individual Compensated		
	Avg % Dev	Lowest Underest.	Highest Overest.
CCMein	0.0%	-8.0%	+5.8%
BeefPat	0.0%	-5.2%	+3.9%
BeefHash	0.0%	-14.1%	+8.2%
PotatBac	0.0%	-8.4%	+6.6%
	Individual Compensated		
	Avg cc Dev	Lowest Underest.	Highest Overest.
CCMein	0cc	-15cc	+8cc
BeefPat	0cc	-15cc	+10cc
BeefHash	0cc	-18cc	+11cc
PotatBac	0cc	-11cc	+8cc

Again, offsetting the regression results would eliminate any underestimating as detailed before. In this case, the offsets would be, as respectively, 15cc, 15cc, 18cc, and 11cc.

	Offset, Regression Compensated		
	Avg cc Dev	Lowest Underest.	Highest Overest.
CCMein	+15cc	0cc	+23cc
BeefPat	+15cc	0cc	+25cc
BeefHash	+18cc	0cc	+29cc
PotatBac	+11cc	0cc	+19cc

The result would be that the non-destructive tester would, again, always overestimate gas volume. At most, it would overestimate as little as 19cc for PotatBac, or as much as 29cc for BeefHash.
A discussion of results of the Beef Patties in Brine continued, since the product was significantly above specifications. It was hypothesized that vacuum application may cause air to be drawn out that might not be measured destructively without vacuum having been applied.
The group moved the plant for a unit demonstration. One BeefPat tray was tested in the tester. The direct result was 241cc. The gas was then measured destructively in the lab to be 285cc. Applying the uncompensated offset (+49cc) for BeefPat predicted 290cc.
A second tray was measured destructively, without having any vacuum applied to it previously. It had 270cc of headspace gas.
The group returned to the conference room to discuss the test results and next steps.
The following were given by the presenter;
• Purchase tester from Precision Automation
• Ship unit back to producer site to continue Phase III testing protocol
• Continued support of unit
– Analysis of producer data
– Field design changes
– Explore an Auto height adjustment to eliminate shim step

Discussion shifted to the requirement of producers to measure gas for retorting regulatory compliance. Producers must control the gas headspace to remain within parameters defined by the retort process. Too much headspace will cause a tray to be under processed.
A government representative said that the government should not require end item inspection if producers must maintain process control measures and measure gas in process. End item inspection for residual gas should be phased out.
The discussion turned to if the tester could be used for regulatory compliance. A producer felt the precision and accuracy of the tester (as currently configured) are insufficient to replace the destructive method for regulatory compliance. It was discussed that +-5cc would be acceptable. What the retort process limits are compared to the current 250cc government limit was notably not discussed. Individual companies will define processes with safety margins since process deviations can cause potentially lethal, under processed products.
The discussion turned to next steps. The scope of the project has completely changed;
It is no longer a tester to measure gas for quality assurance.(+-10%, or -0%+20%).
It is to be an instrument for retorting regulatory compliance. (+-5cc)
The PI was asked to present the IPR results at the next CORANET workshop to solicit additional

input and suggestions on improving the system.
Additional fine tuning in light of the scope change will be carried out in the meantime to improve the system. A study of the effect of an automatic height adjustment mechanism will be tested to see if it improves results. A no cost, extension to July 31, 2006, was requested.
June 2006 - Work on improving system repeatability and accuracy is continuing. Results from automatic height adjustment experiments are not encouraging. Only slight improvements in accuracy were noted. Repeatability standard deviation is not within +-5cc. An alternative algorithm designed to estimate plate contact area yields better results. Repeatability improved to within +-5cc of multiple measurements, but systematic measurement error increased deviation to approximately +-12cc for Beef Patties.
July 2006 - CORANET Workshop project briefing in Portland, Oregon. Work continued on improving the existing system to improve repeatability. Automatic height adjustment experiments yielded marginal improvement. Repeatability standard deviation is not within +-5cc. CORANET members were briefed at the workshop on the IPR results of the analysis of the four products supplied by DDJC. The unit met the goal of measuring on average within -0%+20% of destruct measurements. Industry suggested a design goal change from +-10% to -0%+20% to provide a clearer indication of product quality. Data points out of specification as shown during the presentation would present no operational issue since headspaces for these trays were substantially below the current limit of 250cc. All machine measurements were at or above the destructive measurements. Using the machine as a QA tool would require a test run of at least 25 trays for each other product to determine offsets of direct measurements. The results of applying regression analysis using weight were also presented to show the potential for enhanced accuracy. Improvement was seen in three of the four products tested.
An alternative algorithm designed to estimate plate contact area yield better results. Repeatability improved to within +-5cc of multiple measurements, but systematic measurement error increased standard deviation to approximately +-12cc for Beef Patties.
The scope change, (+-10% to +-5cc), has created a significant challenge to the overcome. There were suggestions made by partners since the workshop and a discussion with Precision Automation has produced even more possibilities. Another university partner suggested using a displacement sensor instead of a force sensor. Precision Automation stated they will source one and report back with a time schedule. Once another sensor is installed, reprogramming, testing and data analysis is estimated to require about 3 weeks.
The current force sensor was replaced with a higher capacity model to improve accuracy of the model several program changes back. The lower capacity model had better repeatability at lower ranges of measurement. Since the algorithm has changed significantly, a test will be run with the other sensor to determine if it will improve repeatability and accuracy. Re-installation of the sensor, testing, and data analysis will require 1 week.
These supplemental tasks would require an extension to September 30th, and an incremental funding increase to cover task labor, F&A, etc. and machine rental. A request was made to cover these new tasks. Phase III is complete. Supplemental tasks to explore suggested hardware changes are recommended. Work to be completed by September 30, 2006.
August 2006 - Supplemental tasks and project extension to September 30 were approved. Teleconference with Precision Automation took place. Precision Automation responded to the request for a schedule to retrofit a displacement sensor in place of the existing force transducer. The details of using a displacement sensor were discussed during a teleconference with the Engineering Dept. at Precision Automation. The recommended displacement sensor would require machining a larger chamber lid to accommodate increased sensor travel. The signal response from a displacement sensor is significantly different from a force transducer and would require different input modules, a signal amplifier, a conditioning board, and extensive software reprogramming. Precision Automation estimated the job would require three months after all hardware was in house. Additional engineering labor costs would exceed $4000, in addition to the hardware estimate exceeding $3000.
An alternative strategy was suggested. Using a force sensor with significantly lower capacity could be used to measure displacement with no additional hardware or software changes. The current sensor is rated to measure 200kg. An alternative sensor measuring only up to 20kg was recommended to increase sensor displacement over the current unit by a factor of 10. The gas

calculation algorithm could be modified to account for the change in sensor response. In effect, the sensor would act like a displacement sensor with a fixed start point.

Using automatic height adjustment experiments of using varying shims to simulate alternate heights, a force transducer would accurately reflect the response of a displacement sensor without the expense and time required to re-engineer the Precision Automation system. Based on Precision's recommendation, it was decided to order a 20kg sensor and send the re-calibration system to the FMT Facility with it when it arrived. Phase III is complete. Supplemental tasks to explore suggested hardware changes were approved. Work to be completed by September 30, 2006.

September 2006 - Phase III and supplemental tasks are complete.

The calculation module was reprogrammed to include the increased sensor displacement. A 20kg sensor and the re-calibration system were delivered from Precision Automation. The sensor was installed and re-calibrated. Experiments were completed using multiple shims to simulate the system response of a displacement sensor. The sensor delivered had a different connector from the existing unit. Precision sent replacement connectors and a wiring schematic. Installation required rewiring connectors through the control cabinet chassis.

The main focus of the displacement sensor simulation experiments was on determining measurement repeatability. Fine tuning the system parameters resulted in system standard deviation ranging from +-5% to +-8% over 20 measurements for the four products tested. Reliance on two data points, instead of four as previously modeled, did not improve results as originally hypothesized. The decreased systematic error of using only two data points was offset by the non-linear response of the tray expansion at lower vacuum levels. Increasing vacuum levels would overload the sensor. At higher vacuum levels, the tray lid would fully expand. Without a means to accurately quantify the tray lid area of expansion, variation from test to test could not be factored out. In short, the application of a displacement sensor system did not improve system's main shortcoming in producing results of +-5cc, repeatability. However, the system met the original design criteria of +-10% for the products tested. The unit was crated and awaits pick up by Precision Automation.

Precision Automation is scheduled to pick up the crated unit by early October.

2.5. Final Report

This document is the final report for this Short Term Project.

3. Program Management

The project was awarded on March 4, 2003 under contract SP0103-02-D-0024, delivery order 0007 with an initial obligation of $163,881.30. Performance period for this delivery order was originally set for 03/04/04.

The following modifications were issued:

Date	Modification	Description
03/01/04	0007/01	Performance period extended from 03/04/04 to 05/03/04.
05/03/04	0007/02	Performance period extended from 05/03/04 to 08/04/04.
08/03/04	0007/03	Performance period extended from 08/04/04 to 12/04/04.
12/03/04	0007/04	Performance period extended from 12/04/04 to 03/14/05.
01/28/05	0007/05	Increase of obligation from $163,881.30 to $191,926.30.
03/11/05	0007/06	Performance period extended from 03/14/05 to 04/14/05.
04/13/05	0007/07	Performance period extended from 04/14/05 to 05/31/05.
05/27/05	0007/08	Performance period extended from 05/31/05 to 11/30/05.
07/05/05	0007/09	Increase of obligation from $191,926.30 to $269,869.30.
11/29/05	0007/10	Performance period extended from 11/30/05 to 05/31/06.
05/30/06	0007/11	Performance period extended from 05/31/06 to 07/31/06.
07/31/06	0007/12	Increase of obligation from $269,869.30 to $295,326.30 and Performance period extended from 07/31/06 to 09/30/06.

COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

Universal Bench Top Package Tester

Bench Top Tester Prototype

OBJECTIVE

Acquire and evaluate Multi Purpose Vacuum Test Unit that can be used to measure residual gas volume in packages and evaluate systems improvements to Package Integrity Test protocols.

BENEFITS

- **Reduced cost: Non-destructive testing reduces product waste**
- **Increased quality: Increased product testing**
- **Low risk and low cost assessment and validation of new technologies and testing methods**

BUSINESS STRATEGY

- **Annual Ration Production: Tray Pack and MRE Production**
- **Developing Partners: Rutgers, Ration Producers**
- **Demonstration Site: Rutgers FMT Facility**
- **Duration: 12 months**

RELATED EFFORTS

- **STP1020: "Tray Pack Integrity Tester"**
- **STP1019B: "MULD Upgrades"**

IMPLEMENTATION

- **Phase I: Detailed Design and Software Specification**
- **Phase II: Subcontracting and Fabrication**
- **Phase III: Implement and Evaluation**

CORANET II

PROJECT, GOALS, MILESTONES, METRICS CHART

Project Title: Universal Bench Top Package Tester

Project Tasks:

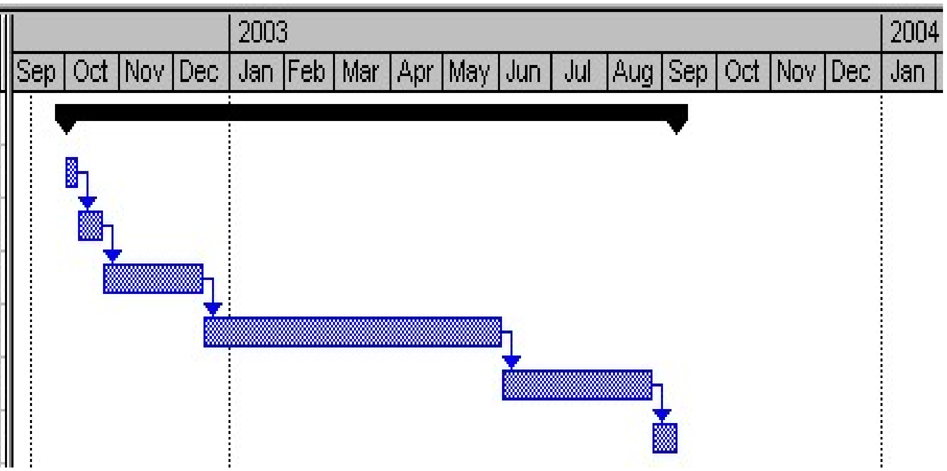
- **Detailed Design and Software Specification**
  - Incorporate flexibility and modularity into chamber and control design
  - Address weaknesses of polytray integrity tester as residual gas tester
    - » Software Interface and calculation algorithm
    - » Automatic sensor height adjustment
  - Apply solutions to address weaknesses experienced with MULD tester
    - » Automated force analysis
    - » Automated Software Recipe Development
- **Subcontracting and Fabrication**
  - Solicitation
  - Subcontract award
- **Implementation and Evaluation**
  - Polytray testing for leaks, weak seal and residual gas
  - MRE Testing for leaks, weak seal and residual gas

COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

Time Table

Task Name	Duration	Start	Finish
Universal Tester	**245 days**	**Tue 10/1/02**	**Mon 9/8/03**
Specification	5 days	Tue 10/1/02	Mon 10/7/02
Solicitation	10 days	Tue 10/8/02	Mon 10/21/02
Sub Contractring	40 days	Tue 10/22/02	Mon 12/16/02
Fabrication	24 wks	Tue 12/17/02	Mon 6/2/03
Testing	12 wks	Tue 6/3/03	Mon 8/25/03
Documentation	2 wks	Tue 8/26/03	Mon 9/8/03



COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

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IMPLEMENTATION

•Phase I: Engineering Analysis
•Phase II: Contracting and Fabrication
•Phase III: Product Testing and Evaluation
•Phase IV: Evaluation at Producers

CORANET II

Universal Bench Top Package Tester Project Tasks

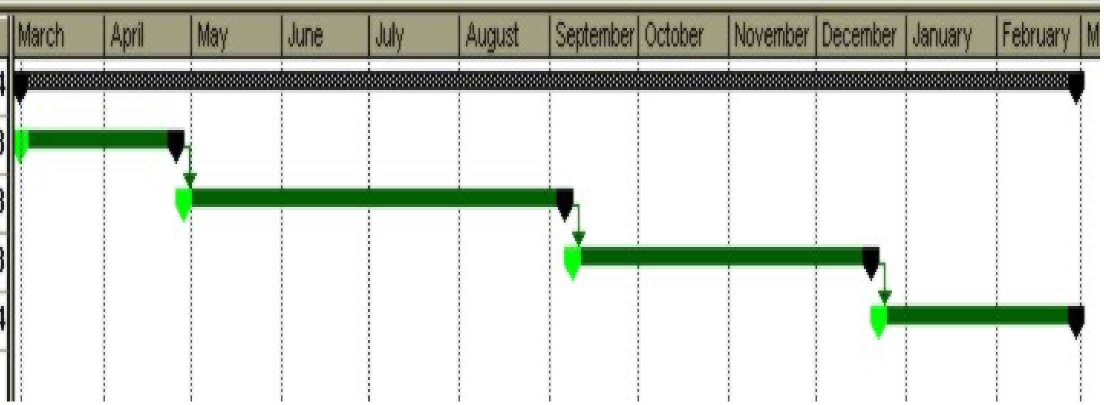
- **Phase I Pre-Engineering Analysis**
  - **Develop hardware and software specifications**
  - **Conduct a literature search and solicit lease proposals**
  - **Conduct a cost/benefit analysis of proposals**
  - **In Process Review Meeting**
- **Phase II Contracting and Fabrication**
  - **Evaluate proposals and issue purchase order based on IPR**
  - **Request samples of all applicable packages from all producers**
  - **Manage and report on fabrication progress**
- **Phase III Product Testing and Validation at the Demo Site**
  - **Schedule and conduct tests on products received**
  - **Document findings and record force slopes and constants**
  - **Issue Interim Technical Report**
- **Phase IV Evaluation in Producer Plants**
  - **Visit each producer, provide support during tests and report results**
  - **Collect NCIC cost/benefit information at producers**
  - **Conduct final NCIC cost/benefit analysis**
  - **Final Report and purchase recommendation**

COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

Time Table

Task Name	Duration	Start	Finish
Universal Benchtop Package Integrity Tester	260 days	Mon 3/3/03	Fri 2/27/04
Phase I (Pre-Engineering Analysis)	40 days	Mon 3/3/03	Fri 4/25/03
Phase II (Subcontracting and Fabrication	95 days	Mon 4/28/03	Fri 9/5/03
Phase III (Product Testing and Evaluation	75 days	Mon 9/8/03	Fri 12/19/03
Phase IV (Evaluation at Producers)	50 days	Mon 12/22/03	Fri 2/27/04



COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

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IMPLEMENTATION

- **Phase I: Engineering Analysis**
- **Phase II: Contracting and Fabrication**
- **Phase III: Product Testing and Evaluation**
- **Phase IV: Evaluation at Producers**

CORANET II

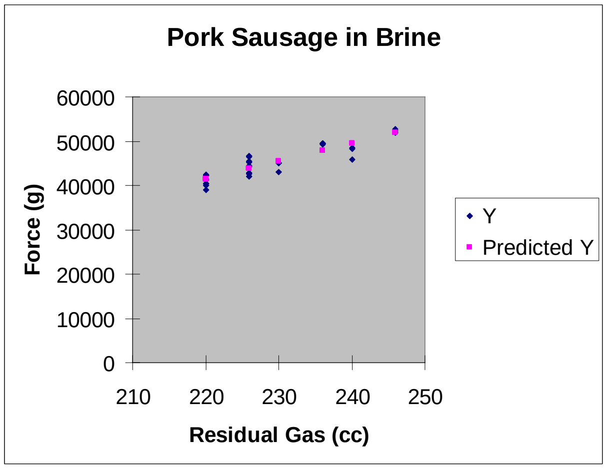
Universal Bench Top Package Tester Project Tasks

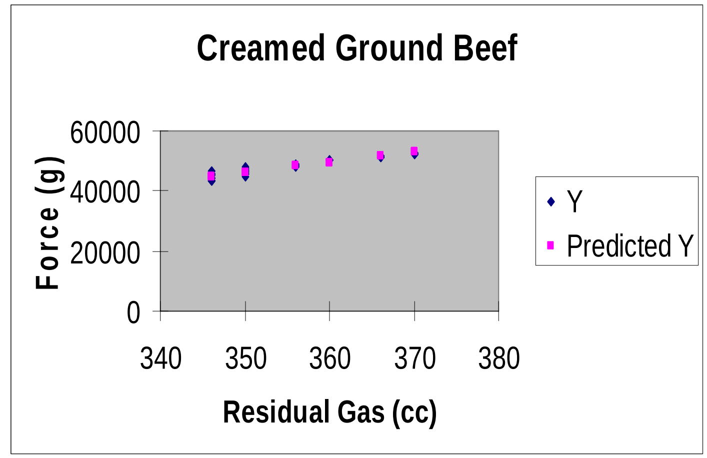
- **Highlights of activities through June 26**
  - **Bids solicited for machine alterations to test using traypacks**
    - » **Precision Automation $1000**
    - » **PTI Inc. $6800**
    - » **iTi-Qualitek N/A**
  - **PO issued to Precision, chamber completed, tests runs done 6/19-6/20**
  - **Data analysis of tests completed**
  - **Schematics released from PTI for RU IE dept. to fabricate insert for <$1000**
  - **Materials ordered and delivered to IE dept.**
  - **Work to be completed by July 11.**
  - **Tests at PTI to be scheduled upon insert completion**

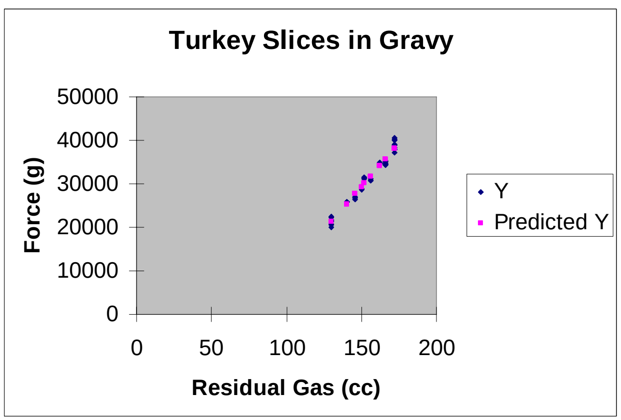
COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

Data Summary from Precision Automation Prototype Testing

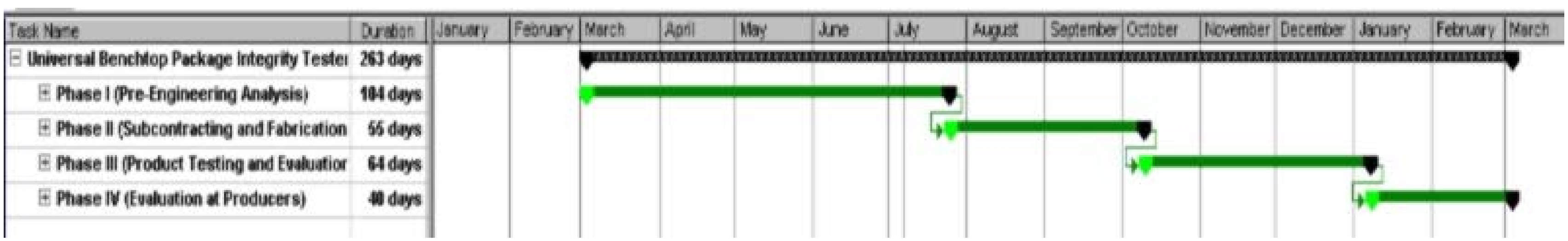






Regression Statistics		
Pork	Multiple R	0.916298
Beef	Multiple R	0.94993
Turkey	Multiple R	0.986715

Time Table


Task Name
Duration
January
February
March
April
May
June
July
August
September
October
November
December
January
February
March
Universal Benchtop Package Integrity Tester
263 days
Phase I (Pre-Engineering Analysis)
104 days
Phase II (Subcontracting and Fabrication
55 days
Phase III (Product Testing and Evaluation
64 days
Phase IV (Evaluation at Producers)
40 days

COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

Universal Bench Top Package Tester, STP 2002

Bench Top Tester Prototype

OBJECTIVE

Acquire and evaluate Multi Purpose Vacuum Test Unit that can be used to measure residual gas volume in packages and evaluate systems improvements to Package Integrity Test protocols.

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BUSINESS STRATEGY

- **Annual Ration Production: Tray Pack and MRE Production**
- **Developing Partners: Rutgers, Ration Producers**
- **Demonstration Site: Rutgers FMT Facility**
- **Duration: 12 months**

RELATED EFFORTS

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•STP1019B: “MULD Upgrades”

IMPLEMENTATION

•Phase I: Engineering Analysis
•Phase II: Contracting and Fabrication
•Phase III: Product Testing and Validation
•Phase IV: Evaluation at Producers

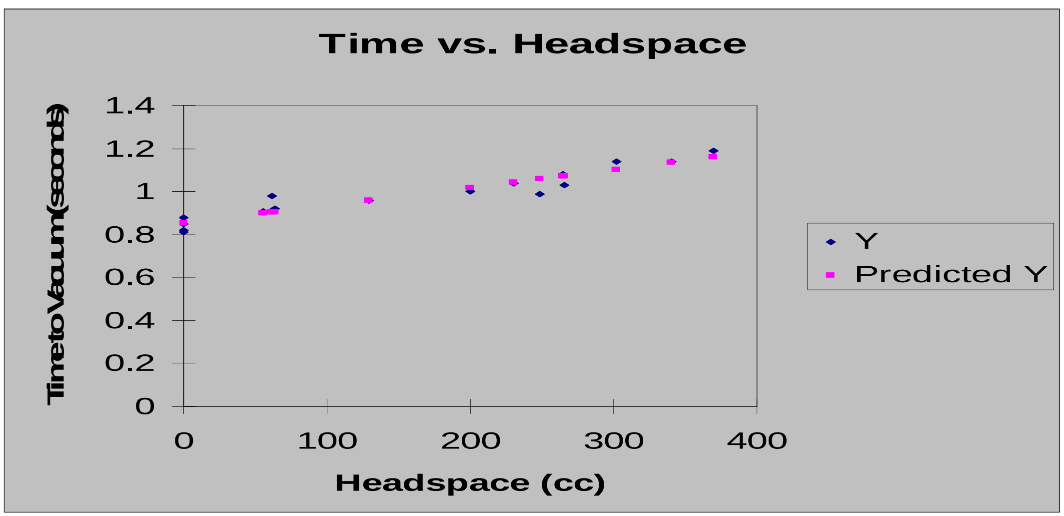
CORANET II

Universal Bench Top Package Tester Project Tasks

- **Phase I Engineering Analysis**
  - Develop testing specifications
  - Conduct a literature search
  - Solicit lease proposals
  - Evaluate prototype performance, analyze test results
  - Interim Technical Review
- **Phase II Contracting and Fabrication**
  - Evaluate proposals and issue purchase order based on ITR
  - Request samples of all applicable packages from all producers
  - Manage and report on fabrication progress
- **Phase III Product Testing and Validation at the Demo Site**
  - Schedule and conduct tests on products received
  - Document findings and record parameters and constants
  - Issue Interim Technical Report
- **Phase IV Evaluation in Producer Plants**
  - Visit each producer, provide support during tests and record results
  - Collect NCIC cost/benefit information at producers
  - Conduct final NCIC cost/benefit analysis
  - Final Report and purchase recommendation

PTI - USA Tester Evaluation

- Technology & Testing Methodology
  - Time chamber evacuation
    - » Evacuate chamber with polytray until vacuum set point achieved
    - » Measure time to reach vacuum set point
    - » Correlate evacuation time to headspace volume
  - PTI requested sample trays filled with known volumes of water
    - » Tests were repeated 4x on 16 water trays, gas measured same day
    - » 4 Pork Sausage and Turkey Slice trays also tested
- **Results - Water**
  - Regression analysis for Time to Headspace indicates R^2=0.91
  - Headspace estimates from regression constants vs. actual, range +60% to -50%
  - Average absolute deviation of estimated headspace to actual, 13.5%
- **Results - Pork & Turkey Tray regressions inconclusive**



Uson / iTi-Qualitek Tester Evaluation

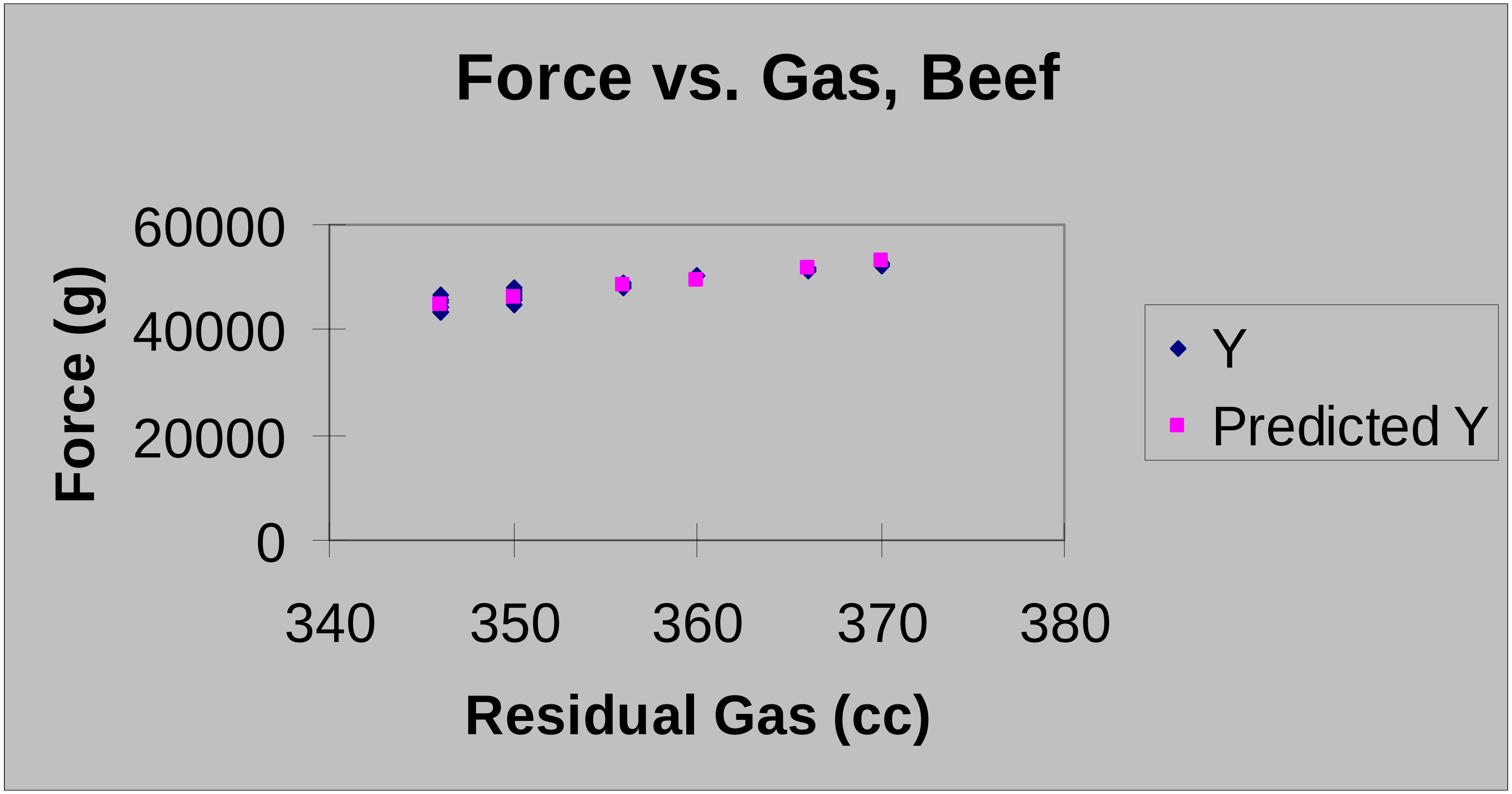
- Technology & Testing Methodology
  - Force measurement of lid deflection under vacuum
    - » Adjust plate height manually until it touches lid
    - » Evacuate chamber with polytray until vacuum set point achieved
    - » Measure force applied to plate above lid at vacuum set point
    - » Correlate force to headspace volume
  - Uson provided prototype unit and support for sample testing
    - » 12 trays, 4 of each; Turkey, Pork Sausage, & Creamed Beef tested
    - » Silicone beads applied to allow addition of air and water
    - » Conditions; Baseline, +10cc Air, +20cc air, +10cc H_20, +20cc H_20
    - » Each condition tested 4 times and data recorded to disk
    - » Gas measured destructively at Uson the same day
- Results - Regression analysis inconclusive
    - » Plate force highly dependent on plate height adjustment
    - » Slight variation of height adjustment significantly alters force readings
    - » Repeatability of height adjustment critical to functionality
    - » Single measurement algorithm cannot accurately estimate gas volume

Precision Automation Tester Evaluation

- Technology & Testing Methodology
  - Force measurement of lid deflection under vacuum
    - » Insert pre-sized plastic sheets under tray until lid contacts force plate
    - » Evacuate chamber with polytray until vacuum set point achieved
    - » Measure force applied to plate above lid at vacuum set point
    - » Correlate force to headspace volume
  - Precision Automation provided production unit and support for sample testing
    - » 9 trays, 3 of each; Turkey, Pork Sausage, & Creamed Beef tested
    - » Silicone beads applied to allow addition of air and water
    - » Conditions; Baseline, +10cc Air, +20cc air, +10cc H_20, +20cc H_20
    - » Each condition tested 3 times and data recorded to disk
    - » Gas measured destructively the same day
- Experiment Results
    - » Regression correlations for the data collected for beef, pork, and turkey were 0.950, 0.916, and 0.987 respectively.
    - » Headspace estimates from force measurements using regression constants vs. actual;
      - Range for Beef (-1.4%, +1.5%), Pork Sausage (-3.8%, +3.2%), Turkey (-3.6%, +2.6%)
      - Average absolute deviation from actual; Beef (0.6%), Pork Sausage (1.2%), Turkey (1.4%)

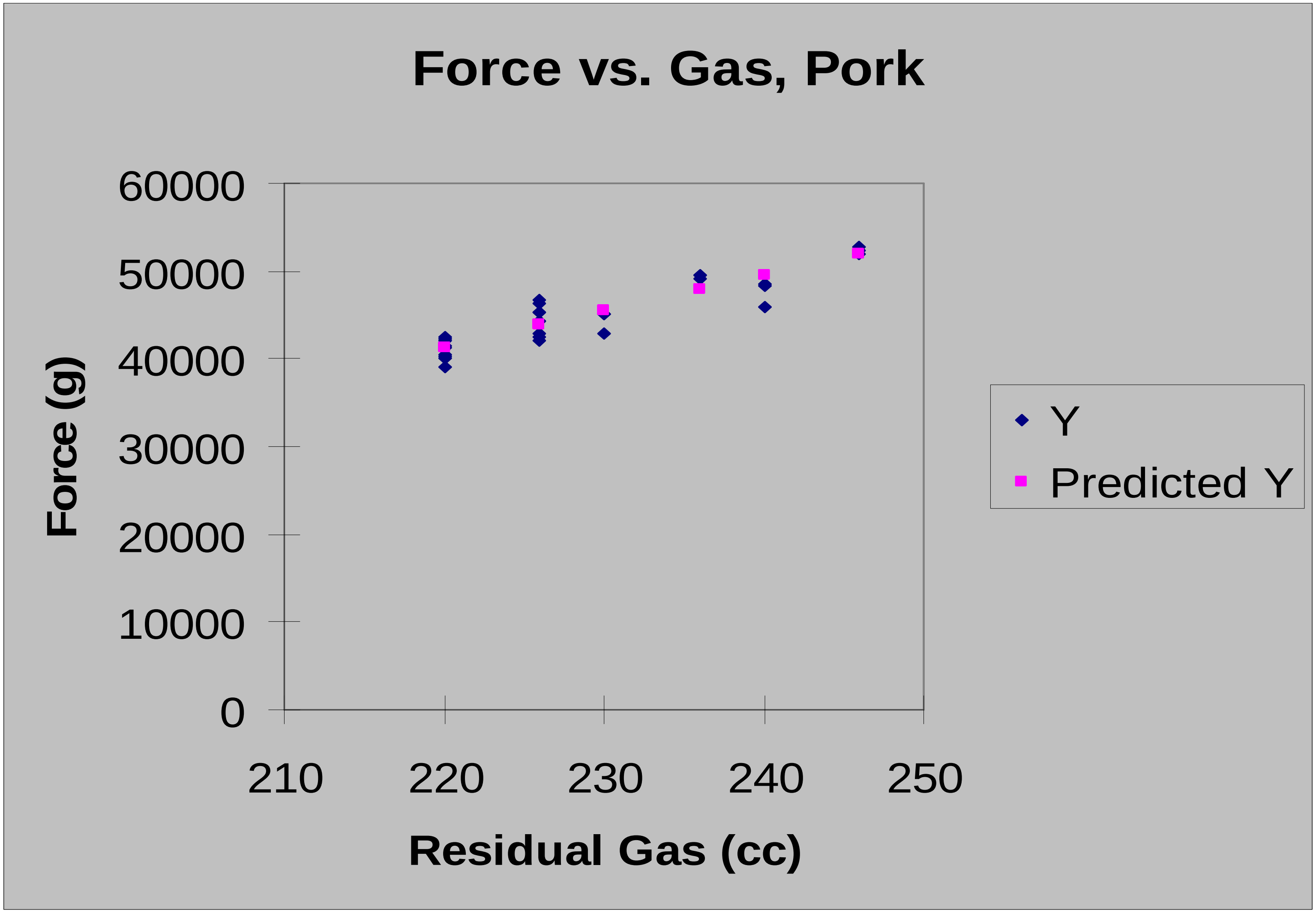
Precision Automation Tester Evaluation

- Results (continued)
  - » Repeatability using pre-sized plates provided consistent height adjustment and better correlation
  - » Algorithm requires significant sampling of trays and data analysis to calculate formula constants



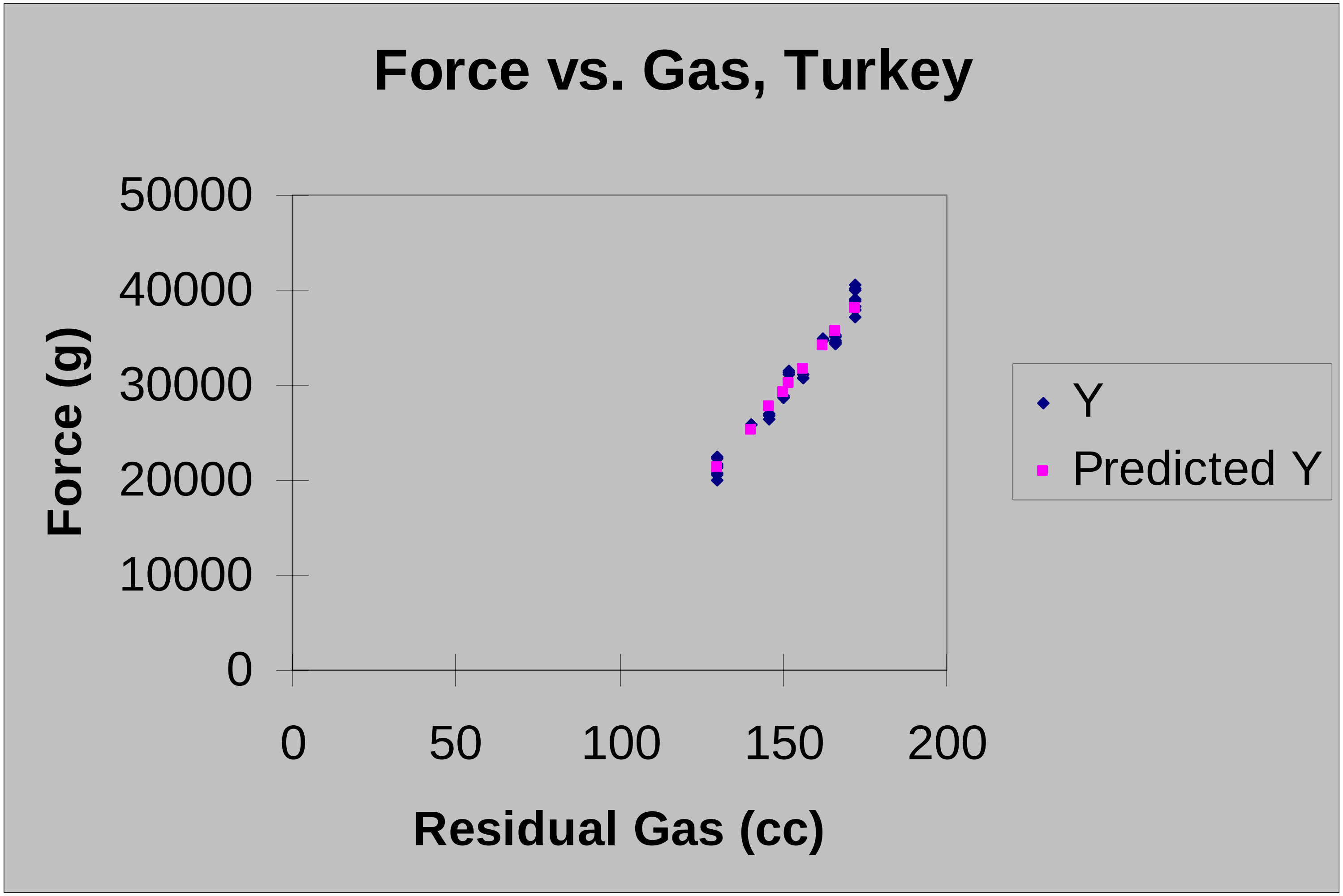
Precision Automation Tester Evaluation

- Results (continued)



Precision Automation Tester Evaluation

- Results (continued)



Recommendation and Next Steps

- Force measurement under vacuum was best method based on polytray testing
- Any self-adjusting pressure plate would require precise control and repeatability
- Currently, the best testing algorithm requires labor intensive and time consuming data analysis to define formula constants. Constants vary for different products.
- An alternative algorithm that has shown some promise in experimental testing uses the principal of Boyle's gas law to calculate residual gas volume based on two measurements of the same tray under different testing conditions.

$$P_0V_0=P_1V_1=P_2V_2 \text{ , Where } P_x=(\text{Air pressure + Force/Plate Area})$$

$$V_x = \text{Gas volume @ pressure}$$

- The estimation model does not depend on fill volume or product density. Preliminary experiments show the model can predict gas volume with repeatable results within certain ranges of plate positioning. More comprehensive experiments are required to better define the model variables.

COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

Universal Bench Top Package Tester, STP 2002

Bench Top Tester Prototype

OBJECTIVE

Acquire and evaluate a Test Unit to measure residual gas volume in packages

BENEFITS

- **Reduced cost: Non-destructive testing reduces product waste**
- **Increased quality: Increased product testing**
- **Low risk and low cost assessment and validation of new technologies and testing methods**

BUSINESS STRATEGY

- **Annual Ration Production: Tray Pack and MRE Production**
- **Developing Partners: Rutgers, Ration Producers**
- **Demonstration Site: Rutgers FMT Facility**
- **Duration: 14 months**

RELATED EFFORTS

•STP2016: "Non-Destructive Seal Testing Polymeric Trays"
•STP1020: “Tray Pack Integrity Tester”

IMPLEMENTATION

•Phase I: Engineering Analysis
•Phase II: Contracting, Product Testing and Validation
•Phase III: Evaluation at Producers

CORANET II

Universal Bench Top Package Tester Project Tasks

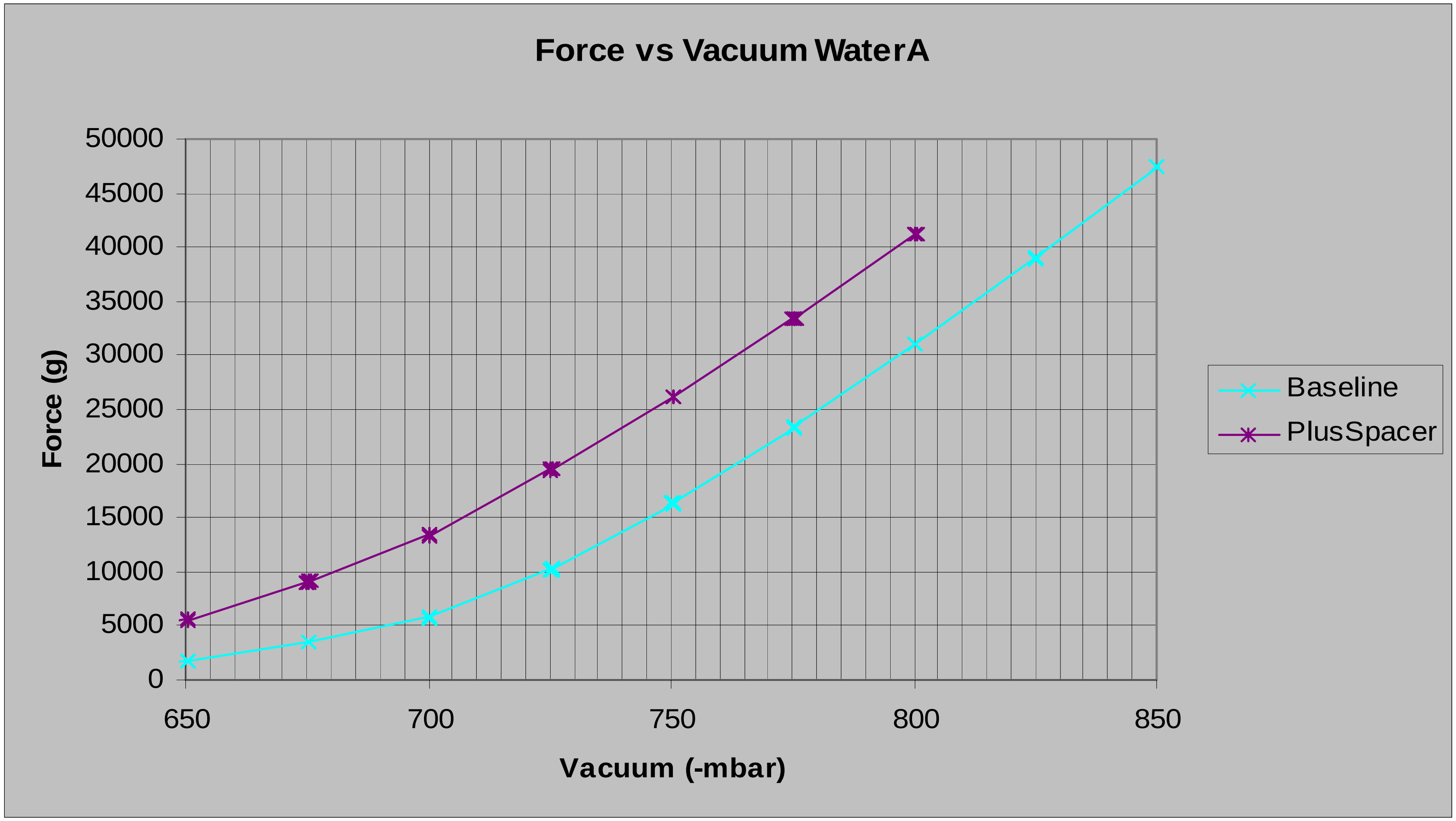
- **Phase I Engineering Analysis**
  - **Develop testing specifications**
  - **Conduct a literature search**
  - **Solicit lease proposals**
  - **Evaluate prototype performance, analyze test results**
  - **Interim Technical Review**
- **Phase II Contracting, Product Testing and Validation at the Demo Site**
  - **Issue purchase order based on ITR**
  - **Manage and report on software progress**
  - **Request samples of all applicable packages from all producers**
  - **Schedule and conduct tests on products received**
  - **Document findings, record parameters and constants**
  - **Issue Interim Technical Report**
- **Phase III Evaluation in Producer Plants**
  - **Visit each producer, provide support during tests and record results**
  - **Collect NCIC cost/benefit information at producers**
  - **Conduct final NCIC cost/benefit analysis**
  - **Final Report and purchase recommendation**

Precision Automation Evaluation II

- Technology & Testing Methodology
  - Force measurement of lid deflection under vacuum
    - » Evacuate chamber with polytray until a set force is achieved
    - » Measure vacuum at force set point, open chamber
    - » Insert pre-sized plastic spacer under tray
    - » Evacuate chamber again to previous vacuum level
    - » Measure force at vacuum set point
    - » Calculate headspace volume from vacuum level and force change
  - Precision Automation provided production unit and support for sample testing
    - » 8 trays tested, 4 Water, 2 Pork Sausage, & 2 Creamed Beef
    - » Gas measured destructively
- Experiment Results: Headspace estimates from force measurements vs. actual;
    - » Ranges for Water, Pork, and Beef; -9.8%, +7.0%
    - » Average absolute deviation from actual; 3.9%

Precision Automation Evaluation II

- Results (continued)
  - » Pre-sized spacer provided consistent height adjustment
  - » Method requires minimal sampling of trays and calculations can be automated



Recommendation and Next Steps

- Experiments show that the alternative method that applies Boyle's gas law can accurately estimate residual gas volume based on two measurements under different testing conditions.

$P_0V_0=P_1V_1=P_2V_2$, Where P_x=(Air pressure + Force/Plate Area)

V_x= Gas volume @ pressure

- The method does not depend on fill volume or product density. The model can predict gas volume with repeatable results within a narrow range of plate heights.
- A larger plate is being fabricated and a request was made for trays from producers to validate the model on additional products.
- Phase I has been extended to May 3, 2004. The ITR will be scheduled after the requested trays are delivered.

COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

Universal Bench Top Package Tester, STP 2002

Bench Top Tester Prototype

OBJECTIVE

Acquire and evaluate a Test Unit to measure residual gas volume in packages

BENEFITS

- Reduced cost: Non-destructive testing reduces product waste
- Increased quality: Increased product testing
- Low risk and low cost assessment and validation of new technologies and testing methods

BUSINESS STRATEGY

- Annual Ration Production: Tray Pack and MRE Production
- Developing Partners: Rutgers, Ration Producers
- Demonstration Site: Rutgers FMT Facility
- Duration: 14 months

RELATED EFFORTS

•STP2016: "Non-Destructive Seal Testing Polymeric Trays"
•STP1020: “Tray Pack Integrity Tester”

IMPLEMENTATION

•Phase I: Engineering Analysis
•Phase II: Contracting, Product Testing and Validation
•Phase III: Evaluation at Producers

CORANET II

INTRODUCTION

- Polytray specifications currently require destructive testing to determine headspace.
- The manual procedure is cumbersome, messy, slow, and expensive.
- Testing frequency is limited due to the cost and waste.
- Tested trays cannot be reworked and represent a significant ongoing expense.
- A non-destructive residual gas tester would allow better process control by increasing the testing frequency and providing faster results.
- A single unit would pay for itself in waste saving in less than 2 years.

CORANET II

Evaluation of Competing Technologies

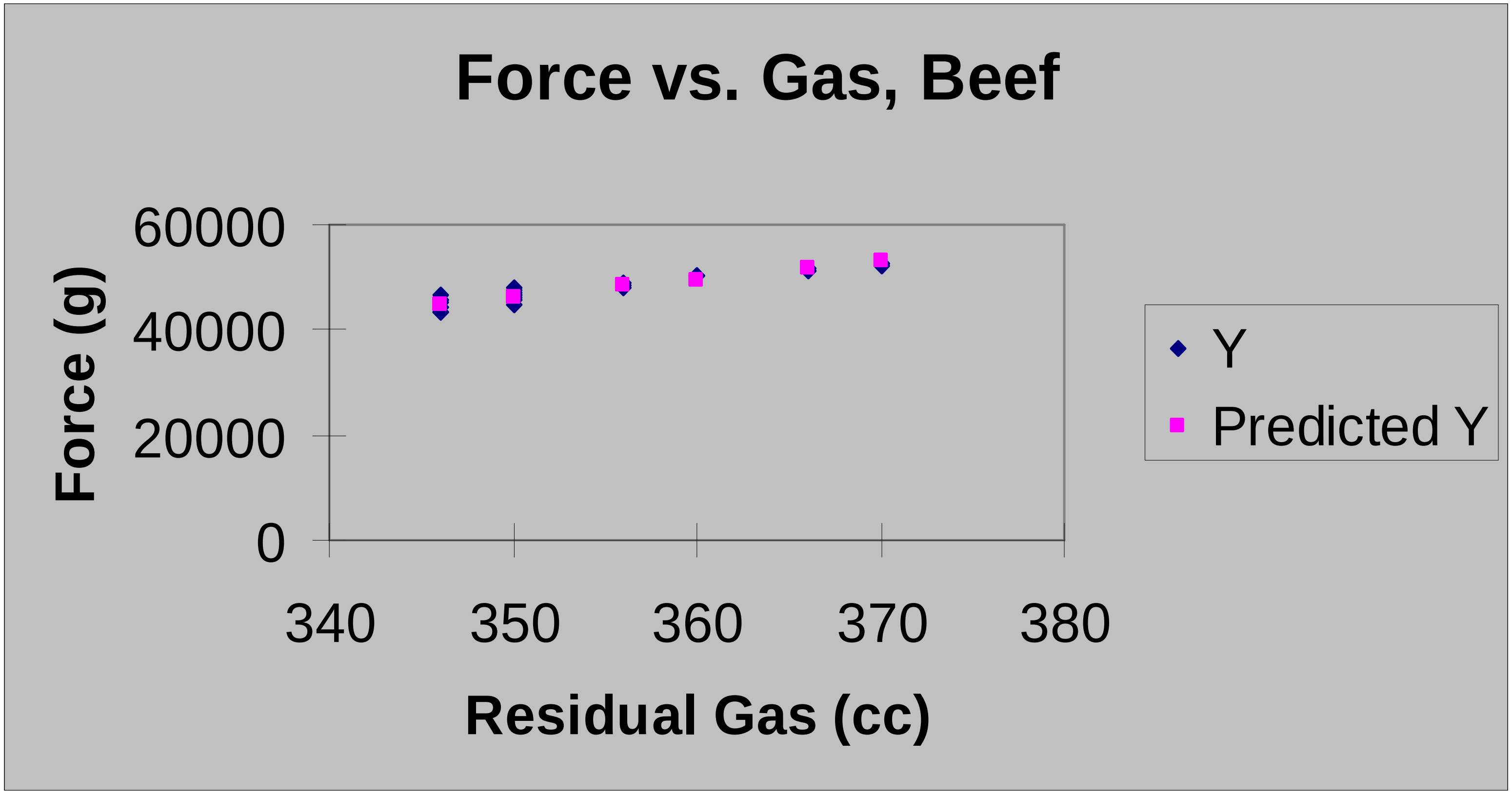
- **Force measurement under vacuum**
  - **Precision Automation, Cherry Hill, NJ**
  - **USON L.P, Houston, TX**
- **Vacuum Decay**
  - **PTI, Tuckahoe, NY**
- **Applied Force response**
  - **None commercially available**
- **Ultrasound**
  - **Not yet applied to packaging volume measurement**

Precision Automation Tester Evaluation

- Technology & Testing Methodology
  - Force measurement of lid deflection under vacuum
    - » Insert pre-sized plastic sheets under tray until lid contacts force plate
    - » Evacuate chamber with polytray until vacuum set point achieved
    - » Measure force applied to plate above lid at vacuum set point
    - » Correlate force to headspace volume
  - Precision Automation provided production unit and support for sample testing
    - » 9 trays, 3 of each; Turkey, Pork Sausage, & Creamed Beef tested
    - » Silicone beads applied to allow addition of air and water
    - » Conditions; Baseline, +10cc Air, +20cc air, +10cc H_20, +20cc H_20
    - » Each condition tested 3 times and data recorded to disk
    - » Gas measured destructively the same day
- Experiment Results
    - » Regression correlations for the data collected for beef, pork, and turkey were 0.950, 0.916, and 0.987 respectively.
    - » Headspace estimates from force measurements using regression constants vs. actual;
      - Range for Beef (-1.4%, +1.5%), Pork Sausage (-3.8%, +3.2%), Turkey (-3.6%, +2.6%)
      - Average absolute deviation from actual; Beef (0.6%), Pork Sausage (1.2%), Turkey (1.4%)

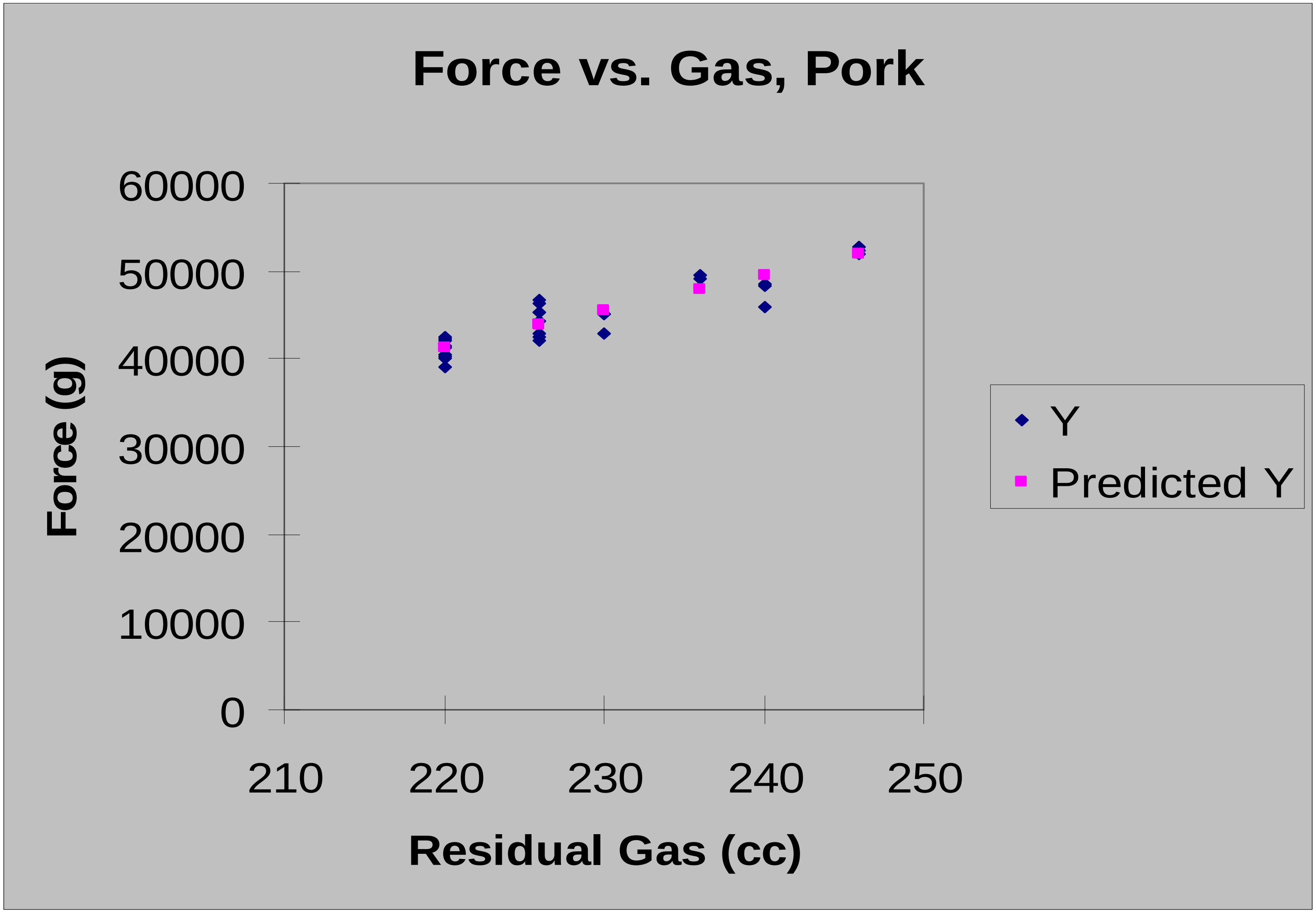
Precision Automation Tester Evaluation

- Results (continued)
  - » Repeatability using pre-sized plates provided consistent height adjustment and better correlation
  - » Algorithm requires significant sampling of trays and data analysis to calculate formula constants



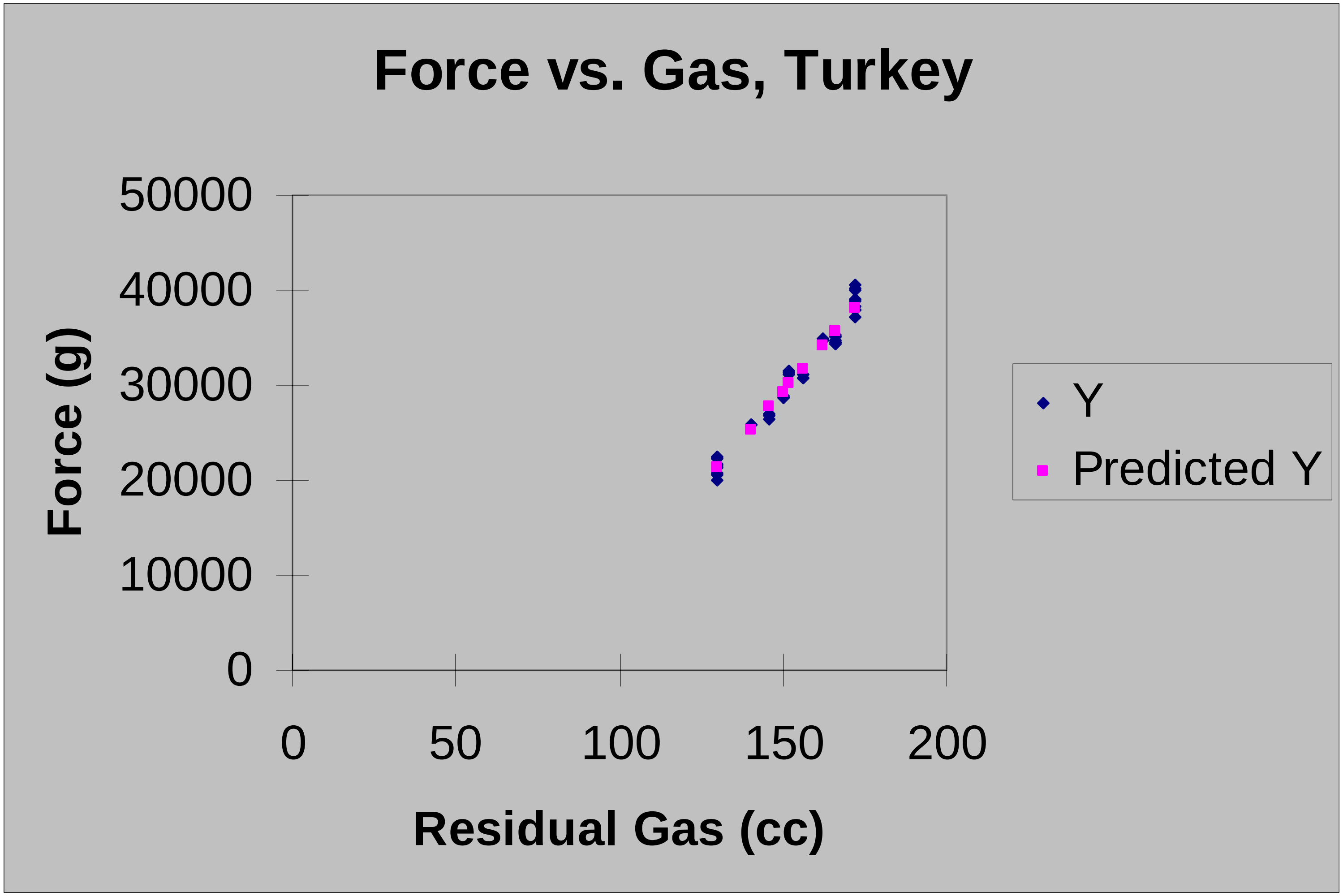
Precision Automation Tester Evaluation

- Results (continued)



Precision Automation Tester Evaluation

- Results (continued)

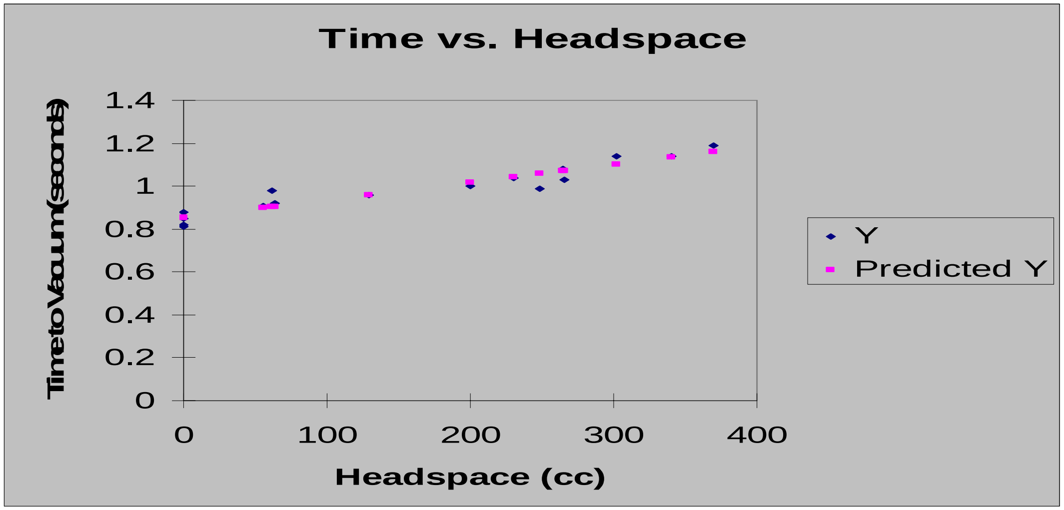


Uson / iTi-Qualitek Tester Evaluation

- Technology & Testing Methodology
  - Force measurement of lid deflection under vacuum
    - » Adjust plate height manually until it touches lid
    - » Evacuate chamber with polytray until vacuum set point achieved
    - » Measure force applied to plate above lid at vacuum set point
    - » Correlate force to headspace volume
  - Uson provided prototype unit and support for sample testing
    - » 12 trays, 4 of each; Turkey, Pork Sausage, & Creamed Beef tested
    - » Silicone beads applied to allow addition of air and water
    - » Conditions; Baseline, +10cc Air, +20cc air, +10cc H_20, +20cc H_20
    - » Each condition tested 4 times and data recorded to disk
    - » Gas measured destructively at Uson the same day
- Results - Regression analysis inconclusive
    - » Plate force highly dependent on plate height adjustment
    - » Slight variation of height adjustment significantly alters force readings
    - » Repeatability of height adjustment critical to functionality
    - » Single measurement algorithm cannot accurately estimate gas volume

PTI - USA Tester Evaluation

- Technology & Testing Methodology
  - Time chamber evacuation
    - » Evacuate chamber with polytray until vacuum set point achieved
    - » Measure time to reach vacuum set point
    - » Correlate evacuation time to headspace volume
  - PTI requested sample trays filled with known volumes of water
    - » Tests were repeated 4x on 16 water trays, gas measured same day
    - » 4 Pork Sausage and Turkey Slice trays also tested
- **Results - Water**
  - Regression analysis for Time to Headspace indicates R^2=0.91
  - Headspace estimates from regression constants vs. actual, range +60% to -50%
  - Average absolute deviation of estimated headspace to actual, 13.5%
- **Results - Pork & Turkey Tray regressions inconclusive**

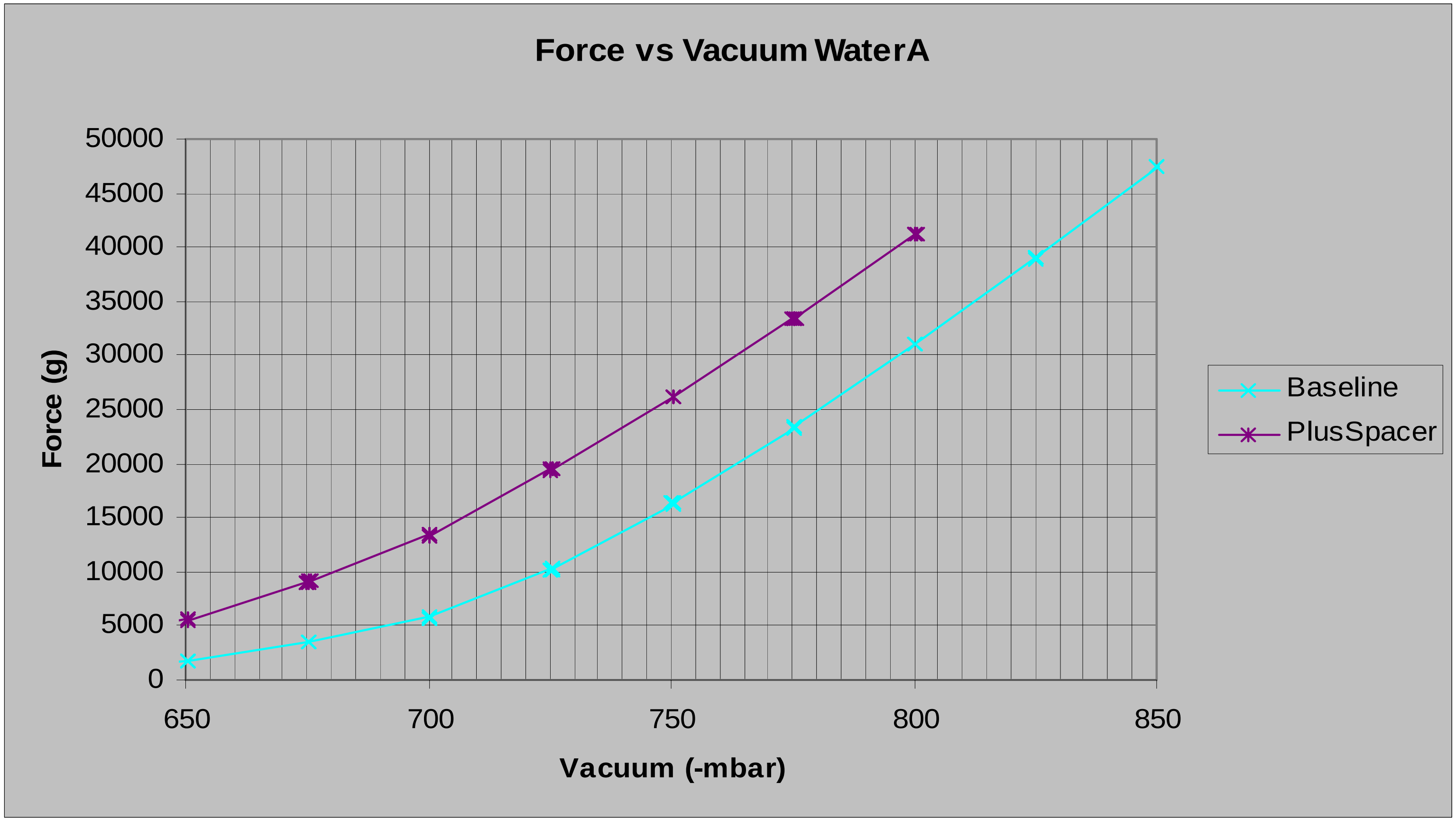


Precision Automation, 2 Point testing

- 2 Measurement Testing Methodology
  - Force measurement of lid deflection under vacuum
    - » Evacuate chamber with polytray until a set force is achieved
    - » Measure vacuum at force set point, open chamber
    - » Insert pre-sized plastic spacer under tray
    - » Evacuate chamber again to previous vacuum level
    - » Measure force at vacuum set point
    - » Calculate headspace volume from vacuum level and force change
  - Precision Automation provided production unit and support for sample testing
    - » 8 trays, Water 4x, Pork Sausage 2x, & Creamed Beef 2x tested
    - » Gas measured destructively
- Experiment Results: Headspace estimates from force measurements vs. actual;
    - » Ranges for Water, Pork, and Beef; -5.3%, +7.0%
    - » Average absolute deviation from actual; 3.4%

Precision Automation, 2 Point Testing

- Results (continued)
  - » Pre-sized spacer provided consistent height adjustment
  - » Method requires minimal sampling of trays and calculations can be automated



Modified 2 Point Testing at FMTF

- 2 Measurement Testing Methodology
  - Force measurement of lid deflection under vacuum
    - » Evacuate chamber with polytray until a set force is achieved
      - Record force/vacuum slope at set point
    - » Measure vacuum at force set point, open chamber
    - » Insert pre-sized plastic spacer on top of tray
    - » Evacuate chamber again to previous vacuum level
      - Record force/vacuum slope at set point to estimate plate area contact
    - » Measure force at vacuum set point
    - » Calculate headspace volume from vacuum level and force changes
- Test Results
  - Wornick provided production samples consisting of 4 products
    - » Ranges for Sample A pumpable, (-0.04%, +3.3%)
    - » Results indicate that some products expand in the 20,000 gram test
      - Setting the force setpoint within the area of gas only expansion predicts best
      - The force setpoint must be determined by review of the force/vacuum slopes
      - Each tray has a different force setpoint that is determined dynamically
      - The method can be easily automated could provide more exhaustive analysis of ranges
    - » Addition experiments required to verify a derived force/vacuum slope can be universally applied. The FMT unit lacks the repeatability required to match the force/vacuum slope in Product A for the other samples.

Recommendation and Next Steps

- The model predicts gas volume without additional correction factors when the setpoint is within the air only expansion slope
- Determination of the best universally applied algorithm based on force/vacuum slope will require additional experimentation
- It is recommended that Phase I be extended so that the remainder of the Wornick samples can be tested in Precision Automation's unit using an automated force setpoint method.

COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

Universal Bench Top Package Tester, STP 2002

Bench Top Tester Prototype

OBJECTIVE

Acquire and evaluate a Test Unit to measure residual gas volume in packages

BENEFITS

- **Reduced cost: Non-destructive testing reduces product waste**
- **Increased quality: Increased product testing**
- **Low risk and low cost assessment and validation of new technologies and testing methods**

BUSINESS STRATEGY

- **Annual Ration Production: Tray Pack and MRE Production**
- **Developing Partners: Rutgers, Ration Producers**
- **Demonstration Site: Rutgers FMT Facility**
- **Duration: 18 months**

RELATED EFFORTS

- **STP2016: "Non-Destructive Seal Testing Polymeric Trays"**
- **STP1020: “Tray Pack Integrity Tester”**

IMPLEMENTATION

- **Phase I: Engineering Analysis**
- **Phase II: Contracting, Product Testing and Validation**
- **Phase III: Evaluation at Producers**

Universal Bench Top Package Tester

- Changes to Gas estimation equation
  - Instantaneous force/vacuum slope used as factor for plate contact area
  - Derived slope factor predicts more accurately than previous method
  - Best results when force slope measures between 0.4 - 0.6.

- Test Results
  - Wornick provided samples of 4 products
    - » Variation of calculated headspace vs. destructive measurements;
      - Pumpables, (-4.0%, +3.3%)
      - Placeables, (-9.0%, +0.3%)
  - Retorted water filled trays
    - » Variation of calculated headspace vs. destructive measurements;
      - Water trays, (-4.4%, +4.8)

- Project Plans
  - Validate model with additional products to be supplied by Wornick.
  - Upon verification of model, Precision Automation will be contracted to program prototype for automated testing and headspace calculation.
  - A hands-on workshop for prototype demonstration and feedback will be scheduled at the FMT Facility when unit is completed.

COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

Universal Bench Top Package Tester, STP 2002

Bench Top Tester Production Unit

OBJECTIVE

Acquire and evaluate a Test Unit to measure residual gas volume in polymeric traypacks

BENEFITS

- **Reduced cost: Non-destructive testing reduces product waste**
- **More frequent product testing: Better quality**
- **Lower risk and lower cost assessment and validation of new technologies and testing methods**

BUSINESS STRATEGY

- **Annual Ration Production: Tray Pack and MRE Production**
- **Developing Partners: Rutgers, Ration Producers**
- **Demonstration Site: Rutgers FMT Facility**
- **Duration: 18 months**

RELATED EFFORTS

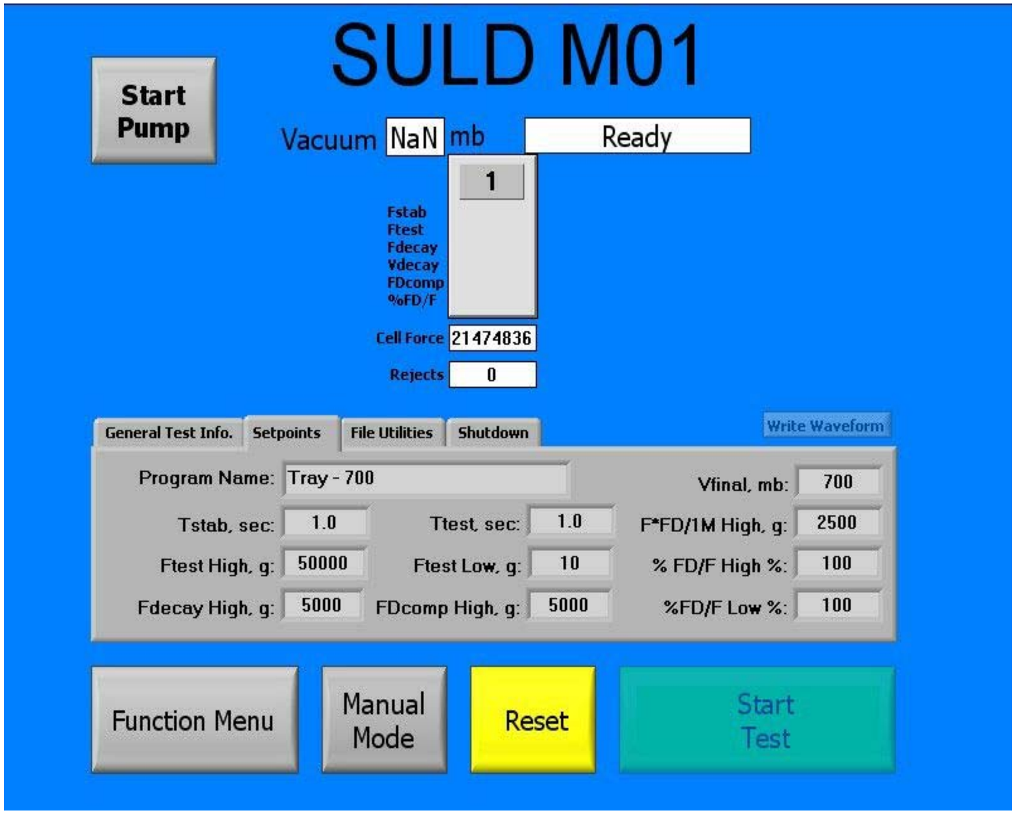
•STP2016: "Non-Destructive Seal Testing Polymeric Trays"
•STP1020: “Tray Pack Integrity Tester”

IMPLEMENTATION

•Phase I: Engineering Analysis
•Phase II: Contracting, Product Testing and Validation
•Phase III: Evaluation at Producers

Universal Bench Top Package Tester

- Precision Automation Tester and Graphical User Interface



Universal Bench Top Package Tester

- Gas volume estimation
  - Method uses two tests on each tray. One with a spacer and one without. During the tests, the following are recorded.
    - » Force on pressure plate (F_1 & F_2)
    - » Chamber air pressure (p_1 & p_2)
    - » Calculation of $\Delta F_X / \Delta p_X$ slope at measurement time
  - Best results when slope is between 0.4 - 0.6.
  - System programming for procedure automation will include simple operator instruction screens, safeties, and interlocks. Automatic plate height adjustment instead of manual spacer can be implemented, but cannot be completed until December-January. The demonstration planned for mid-November will showcase a working unit minus the automated adjustment between tray tests.
  - Programming of Precision Automation unit should be completed by late October.

- Project Plans
  - Modify test chamber to reduce voids and eliminate tray flex
  - Test the new programming with retorted water trays, and on hand inventory from Wornick
  - Demonstration will be scheduled at the FMT Facility after the first software revision is tested

Universal Bench Top Package Tester

- Residual gas estimation methodology and formulas
  - Test 1; Measure Force on plate (F_1), chamber pressure (p_1), & calculate $\Delta F_1 / \Delta p_1$ at test point
  - Test 2; Add spacer (H), Measure F_2, p_2,& calculate $\Delta F_2 / \Delta p_2$ at test point
  - $P_0V_0=P_1V_1=P_2V_2$, solve for V_0
    - » P_0=Atmospheric pressure, 14.7psi
    - » P_X=chamber pressure + (force on plate * contact area)
      - Contact Area estimated by multiplying the instantaneous force/pressure derivative by the total lid area (A).
      - $P_1=p_1+(F_1$*contact area), so $P_1=p_1+((F1*(\Delta F_1 / \Delta p_1))*A)$
      - $P_2=p_2+(F_2$*contact area), so $P_2=p_2+((F2*(\Delta F_2 / \Delta p_2))*A)$
    - » $V_2=V_1$-(spacer height*contact area), where contact area = $((\Delta F_2 / \Delta p_2)$*lid area)
      - $V_2=V_1-(H*((\Delta F_2 / \Delta p_2)*\text{lid area}))$
    - » $P_1V_1=P_2V_2$, so $P_1V_1=P_2 * (V_1-(H*((\Delta F_2 / \Delta p_2)*\text{lid area})))$
      - Solving for V_1, $V_1 = (P_2*(H*((\Delta F_2 / \Delta p_2)*\text{lid area})))/(P_1-P_2)$
    - » $V_0=P_1V_1/P_0$
  - $\therefore$ $V_0=(P_1*((P_2*(H*((\Delta F_2 / \Delta p_2)*\text{lid area})))/(P_1-P_2))/14.7\text{psi}$

STP # 2002

Universal Benchtop Tester

Accomplishments

- Evaluated measurement technologies
- Identified most viable method
- Developed Testing algorithms
- Formulated mathematical model to eliminate product specific constants
- Validated model with industry supplied trays
- Contracted Software development

Cost Benefit

- Producer can audit production non-destructively, leading increased testing and better quality control
- End item test becomes non-destructive
- If all H&S in 2003 was shipped in poly trays, about 57,000 would be used for Residual Gas Testing at a value of $683,000
- Estimated Cost, $35,000/unit
- Payback for 6 unit would be less than 1 year.

Interim Technical Review
STP#2002 Universal Tester:
Non-Destructive Tester for Residual Gas

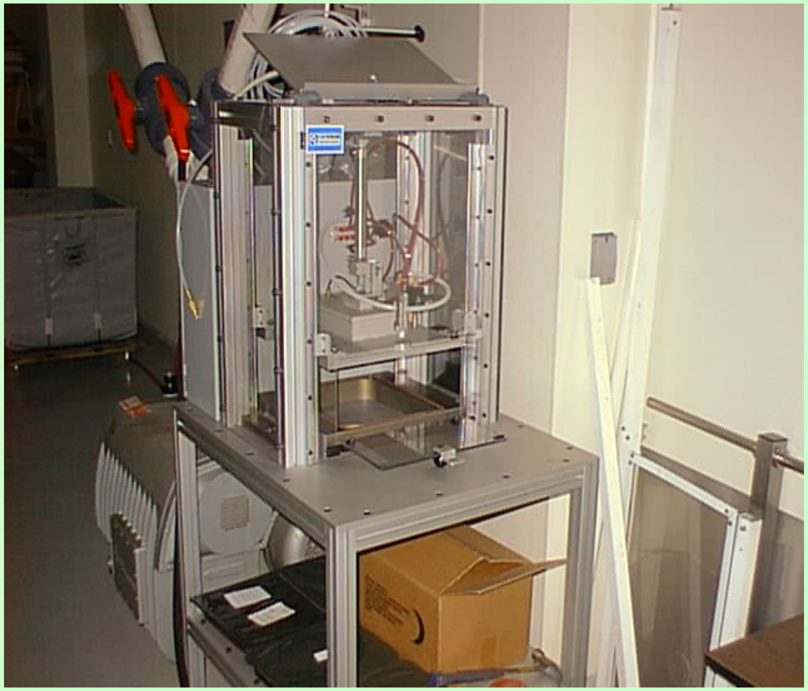
May 6, 2005

PI: Jeffrey Canavan

STP#2002 Presentation Outline

- Review of existing destructive method
- Non-destructive method development
- Recommended algorithm and procedure
- Performance Data
- Plant; Unit Demonstration
- QC Lab; Destruct validation testing
- Next Steps

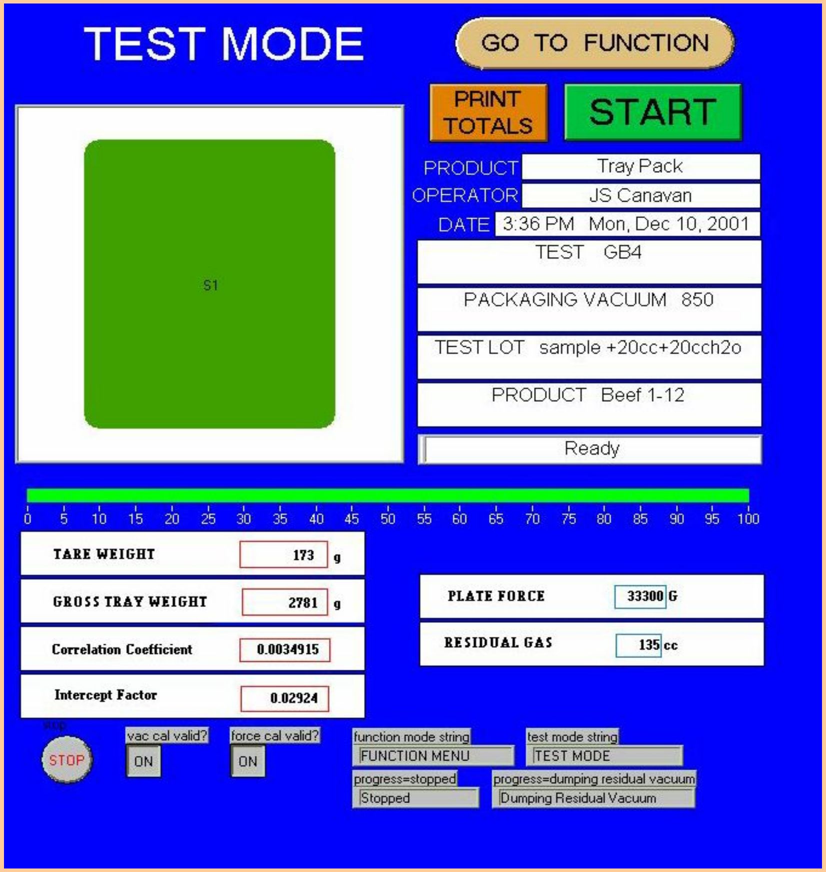
Non-Destructive Method Development



iTi-Qualitek Leak Tester

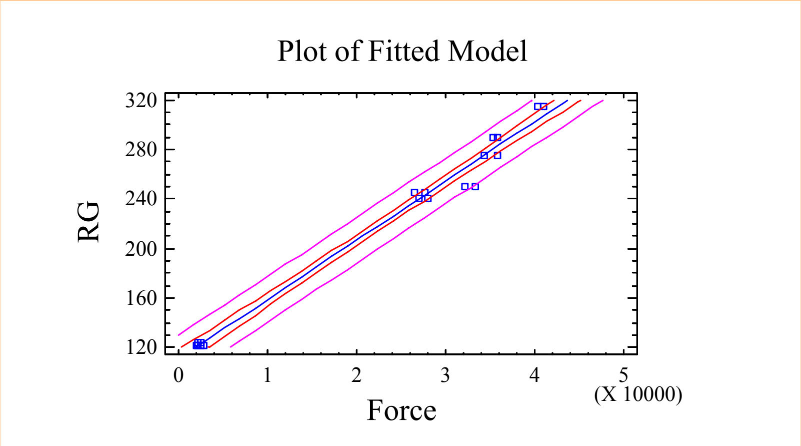
- Data collected during STP#1020 showed Force vs. Vacuum curves correlated with residual gas volume.
- Calculation of volumes required product specific slope factors and constants.
- Slope factor and constant derivation required for each product
- Very tight control of fill volume required for repeatability

STP#1020 Data Summary

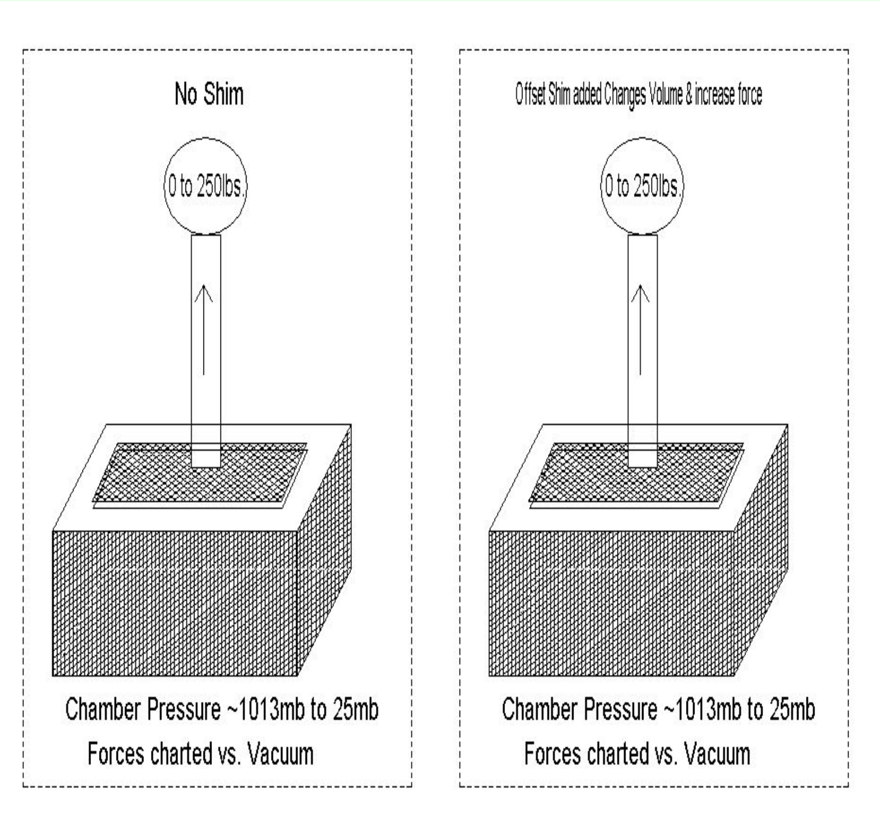


Proposed Interface (12/01)

- Force-Gas model required specific fill weights for accuracy
- Slight changes in fill weight significantly affected results



Force Model Diagram



- Residual gas expands inside tray as vacuum is applied to the chamber.
- Gas pressure deflects lid
- Transducer plate measures force of expanding gases
- An Offset Shim provides ΔV to apply Boyles Gas law; $P1V1=P2V2$.

Boyles Model Development

- Application of Boyles Gas law eliminated need for product specific correlation coefficients
- Model still relied on constants and tight fill control for repeatability
- Experimental validation, regression analysis, and point correlation done manually
- Constant derivation and data processing was time consuming and could not be easily automated
- Measurements from Precision Automation tester using revised formulas yielded repeatable results that varied from destructive measurement +-15% using offset shim plates. Shim heights varied from product to product.

Recent Improvements

- Regression curves for products indicated gas estimates out of measurement range of force sensor (100lbs.)
  - Sensor upgraded to 250lbs. design
- Tray flex reduced by temporary PVC cavity insert
- Method altered to limit systematic error caused by varying tray fill levels
  - Real-time regression analysis carried out at test time
  - Two point selection algorithms explored;
    - Equal Force points and Equal Force Slope Ratios (FSR)
      - Equal Force model compares two points from each curve for the force is equal
      - FSR model compares points with equal instantaneous ΔForce/Δpressure
  - Point-to-point correlations automated for both force-vacuum slopes

Performance Data (FSR Peak)

- Product Trays
  - Beef Hash (135cc)
    - 142cc(+5.2%)
    - 142cc(+5.2%)
  - Beef Patties (295cc)
    - 301cc(+2.0%)
    - 320cc(+8.5%)
  - Beef/Noodles (185cc)
    - 212cc(+14.6%)
    - 209cc(+13.0%)
  - Chicken Brst. (150cc)
    - 160cc(+6.3%)
    - 154cc(+2.6%)
- Water Trays
  - Tray A4 (185cc)
    - 200cc(+8.1%)
    - 201cc(+8.6%)
  - Tray B2 (255cc)
    - 267cc(+4.7%)
    - 268cc(+5.1%)
  - Tray C1 (160cc)
    - 152cc(-5.0%)
    - 153cc(-4.4%)
  - Tray B1 (275cc)
    - 270cc(-1.8%)
    - 273cc(-0.7%)

Demonstration

Next Steps

- Fabricate a permanent metal insert to reduce tray flexing
- Add a UPS/power conditioner to PC
- Ship unit to producer site for extended testing
- Extend unit lease to allow producer to accumulate experience with unit
- Provide additional funding for continued support of unit
  - Phase III
    - Analysis of producer data
    - Field design changes
    - Auto height adjustment to eliminate shim step

COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

Universal Bench Top Package Tester, STP 2002

Bench Top Tester Production Unit

OBJECTIVE

Acquire and evaluate a Test Unit to measure residual gas volume in polymeric traypacks

BENEFITS

- **Reduced cost: Non-destructive testing reduces product waste**
- **More frequent product testing: Better quality**
- **Lower risk and lower cost assessment and validation of new technologies and testing methods**

BUSINESS STRATEGY

- **Annual Ration Production: Tray Pack and MRE Production**
- **Developing Partners: Rutgers, Ration Producers**
- **Demonstration Site: Rutgers FMT Facility**
- **Duration: 24 months**

RELATED EFFORTS

•STP2016: "Non-Destructive Seal Testing Polymeric Trays"
•STP1020: “Tray Pack Integrity Tester”

IMPLEMENTATION

•Phase I: Engineering Analysis (COMPLETE)
•Phase II: Contracting, Product Testing and Validation (COMPLETE)
•Phase III: Evaluation at Producers

Universal Bench Top Package Tester

- Phase II Tasks Completed
  - An improved, more robust force sensor was installed.
  - System changes were incorporated reduce systematic error.
  - Repeatability and accuracy was improved by fine-tuning the regression calculation program.

- IPR Results Summary
  - Unit accuracy demonstrated at +/- 8% of destructive measurement for retorted product supplied by Wornick and FMT water trays.
  - Unit repeatability demonstrated at **+/- 4%**.
  - **Industry was impressed by the performance of the unit and thought that the cost benefit of the unit would allow a quick payback.**

Universal Bench Top Package Tester

- Project Plans
  - Machine a metal tray carrier to replace temporary PVC insert (Rutgers)
  - Complete programming changes (Precision Automation)
    - » Eliminate time delay error on test start up
    - » Add pre-test vacuum step to stabilize headspace
  - Phase III: Unit will be shipped to Producer's plant for implementation (Rutgers)
    - » Validation in production environment of Retorted and Non-Retorted Trays scheduled for 6 months
      - Unit set up, instruction, data collection system connections, and in-Plant observation
      - Coordinate data collection process, provide software support
      - Analyze individual force curve pairs for all test results and correlate products based on temperature and production characteristics.
      - Provide support for program alteration for non-retorted tray testing

COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

Universal Bench Top Package Tester, STP 2002

Bench Top Tester Production Unit

OBJECTIVE

Acquire and evaluate a Test Unit to measure residual gas volume in polymeric traypacks

BENEFITS

- Reduced cost: Non-destructive testing reduces product waste
- More frequent product testing: Better quality
- Lower risk and lower cost assessment and validation of new technologies and testing methods

BUSINESS STRATEGY

- Annual Ration Production: Tray Pack and MRE Production
- Developing Partners: Rutgers, Ration Producers
- Demonstration Site: Rutgers FMT Facility
- Duration: 24 months

RELATED EFFORTS

•STP2016: "Non-Destructive Seal Testing Polymeric Trays"
•STP1020: “Tray Pack Integrity Tester”

IMPLEMENTATION

•Phase I: Engineering Analysis (COMPLETE)
•Phase II: Contracting, Product Testing and Validation (COMPLETE)
•Phase III: Evaluation at Producers (In Progress)

Universal Bench Top Package Tester

- Phase III Tasks Completed
  - Unit was delivered and set up at producers plant
  - Eight operators were instructed on unit use and basic troubleshooting procedures
  - A data transfer protocol was set up to allow remote analysis
  - A series of 10 trays were tested and repeatability was demonstrated to be +/- 6%. Unit accuracy was +/- 12%.

- Project Plans
  - Continue to monitor validation protocol in production environment
  - Coordinate data collection process, provide software support
  - Analyze individual force curve pairs for all test results and correlate products

    based on temperature and production characteristics.
  - Provide support for program alteration for non-retorted tray testing

COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

Universal Bench Top Package Tester, STP 2002

Bench Top Tester Production Unit

OBJECTIVE

Acquire and implement a Test Unit to measure residual gas volume in polymeric traypacks

BENEFITS

- Reduced cost: Non-destructive testing reduces product waste
- More frequent product testing: Better quality, less production put on hold if problems found
- Lower risk and lower cost assessment and validation of new technologies and testing methods

BUSINESS STRATEGY

- Annual Ration Production: Tray Pack and potentially pouch production
- Developing Partners: Rutgers, The Wornick Company
- Demonstration Site: FMT Facility

RELATED EFFORTS

•STP2016: "Non-Destructive Seal Testing Polymeric Trays"
•STP1020: “Tray Pack Integrity Tester”

IMPLEMENTATION

•Phase I: Engineering Analysis (COMPLETE)
•Phase II: Contracting, Testing & Validation (COMPLETE)
•Phase III: Evaluation at Producers (In Progress)

COMBAT RATION NETWORK FOR TECHNOLOGY IMPLEMENTATION

(CORANET)

Automated Vs. Manual Residual Air Testing Results

	Automated (Rutgers Machine)	Manual (Displacement)			
Sample	Retorted, placeable in sauce		Difference		
1	367	360	1.9%		
2	246	240	2.5%		
3	348	340	2.4%		
4	243	240	1.3%		
5	278	280	-0.7%		
6	326	300	8.7%		
7	280	280	0.0%		
8	260	260	0.0%		
	Automated (Rutgers Machine)	**Manual (Displacement)**		AVG	2.0%
Sample	Hot filled, pumpable				
1	252	240	5.0%		
2	194	200	-3.0%		
3	163	180	-9.4%		
4	235	200	17.5%		
5	184	180	2.2%		
6	175	160	9.4%		
7	200	190	5.3%		
8	183	170	7.6%		
				AVG	4.3%

Universal Bench Top Package Tester

- Project Plans
  - Coordinate and schedule a plant visit when polytray production resumes
  - Provide support for program alteration
    - » Hot-filled products
    - » In-process, non-retorted tray testing
  - Monitor validation protocol in production environment
  - Coordinate data collection process, provide software support
  - Analyze collected data from production
    - » Review force curve pairs for all test results
    - » Correlate products based on temperature and production characteristics

Interim Technical Review
STP#2002 Universal Tester:
Non-Destructive Tester for Residual Gas

May 31, 2006

PI: Jeffrey Canavan

STP#2002 Presentation Outline

- Non-Destructive Residual Gas Testing
- Performance Data from DDJC inventory
- Plant; Unit Demonstration
- QC Lab; Destruct validation testing
- Next Steps

Non-Destructive Gas Measurement

- Tray is loaded into chamber
- Stabilization;
  - A high vacuum is applied to tray
  - 90 second hold to stabilize internal gas volume
- Test 1
  - Vacuum is slowly applied to tray
  - Force of tray lid deflection measured
- Operator adds Shim plate
- Test 2
  - Vacuum is slowly applied to tray
  - Force of tray lid deflection measured
- Gas tester outputs result
- Tray is removed; repeat tray loading

Sample Set from DDJC

- 25 trays of four products, 100 total
  - Chicken Chow Mein - Pumpable
  - Beef Patties in Brine - Placeable
  - Beef Hash - Pumpable
  - Potatoes with Bacon

Testing Methodology

- Each tray was weighed and lots were recorded
- Trays were run through tester three times
- Each tray was tapped vigorously on a counter for 60 seconds to move air pocket to the top edge
- Gas was measured using the standard method

Performance Summary

	Direct Measurement Deviation %		
	Avg % Dev	Lowest Underest.	Highest Overest.
CCMein	+6.5%	-5.3%	+16.2%
BeefPat	-9.9%	-16.9%	(-6.1%)still under
BeefHash	+5.9%	-5.6%	+17.3%
PotatBac	+17.3%	(+6.9%)still over	+25.0%
	Direct Measurement cc		
	Avg cc Dev	Lowest Underest.	Highest Overest.
CCMein	+11cc	-11cc	+28cc
BeefPat	-28cc	-49cc	(-17cc)still under
BeefHash	+9cc	-7cc	+20cc
PotatBac	+21cc	(+9cc)still over	+30cc

	Individual Compensated		
	Avg % Dev	Lowest Underest.	Highest Overest.
CCMein	0.0%	-8.0%	+5.8%
BeefPat	0.0%	-5.2%	+3.9%
BeefHash	0.0%	-14.1%	+8.2%
PotatBac	0.0%	-8.4%	+6.6%
	Individual Compensated		
	Avg cc Dev	Lowest Underest.	Highest Overest.
CCMein	0cc	-15cc	+8cc
BeefPat	0cc	-15cc	+10cc
BeefHash	0cc	-18cc	+11cc
PotatBac	0cc	-11cc	+8cc

Demonstration

Next Steps

- Purchase tester from Precision Automation
- Ship unit back to producer site to continue Phase III testing protocol
- Continued support of unit
  - Analysis of producer data
  - Field design changes
  - Explore an Auto height adjustment to eliminate shim step

STP#2002 Universal Tester:
Non-Destructive Tester for Residual Gas

March 2003 – July 2006

STP#2002 Goals and Progress

- Develop a Non-Destructive Residual Gas Tester
- Reduce waste from destructive end item inspection for residual gas
- Improve product quality by increasing testing frequency in-process
- Tester is functional and improvements are being tested to potentially use as a regulatory compliance instrument

Performance Summary

	Offset, Uncompensated		
	Avg cc Dev	Lowest Underest.	Highest Overest.
CCMein	+22cc	0cc	+39cc
BeefPat	+21cc	0cc	+32cc
BeefHash	+16cc	0cc	+27cc
PotatBac	+12cc	0cc	+21cc

	Offset, Regression Compensated		
	Avg cc Dev	Lowest Underest.	Highest Overest.
CCMein	+15cc	0cc	+23cc
BeefPat	+15cc	0cc	+25cc
BeefHash	+18cc	0cc	+29cc
PotatBac	+11cc	0cc	+19cc

Next Steps

- Scope of project has changed significantly
  - No longer a QA tool to improve quality
  - Producer has given +-5cc as level of acceptability for retort regulatory compliance
- Validate auto height adjustability experimentally to determine if +-5cc is possible
- Continue work on Final Technical Report
- Present IPR and recent work at next CORANET workshop to solicit additional ideas and support

Final Technical Briefing
STP#2002 Universal Tester:
Non-Destructive Tester for Residual Gas

July 2006

PI: Jeffrey Canavan

STP#2002 Presentation Outline

- Phase III testing using DDJC Inventory
- Testing Results; Conclusions
- ITR Discussion Notes
- Progress since ITR
- Next Steps

Sample Set from DDJC

- 25 trays of four products, 100 total
  - Chicken Chow Mein - Pumpable
  - Beef Patties in Brine - Placeable
  - Beef Hash - Pumpable
  - Potatoes with Bacon

Testing Methodology

- Each tray was weighed and lots were recorded
- Trays were run through three testing cycles
- Each tray was tapped vigorously on a counter for 60 seconds to move air pocket to the top edge
- Gas was measured using the destructive method

Non-Destructive Gas Measurement

- Tray is loaded into chamber
- Stabilization;
  - A high vacuum is applied to tray
  - 75 second hold to stabilize internal gas volume
- Test 1
  - Vacuum is slowly applied to tray
  - Force of tray lid deflection measured
- Operator adds Shim plate
- Test 2
  - Vacuum is slowly applied to tray
  - Force of tray lid deflection measured
- Gas tester outputs result
- Tray is removed; repeat tray loading

Chicken Chow Mein

Tray ID	Gross Wt.	Gas Est.	Gas cc	Diff cc	Diff %
chixa1	2963	214	184	30	16.3%
chixb1	2970	207	186	21	11.3%
chixc1	2967	220	188	32	17.0%
chixd1	2974	215	180	35	19.4%
chixf1	2983	201	166	35	21.1%
chixg1	2975	213	174	39	22.4%
chixh1	2974	209	172	37	21.5%
chixI1	2993	192	156	36	23.1%
chixJ1	2997	169	136	33	24.3%
chixK1	2992	181	150	31	20.7%
chixL1	2997	183	150	33	22.0%
chixM1	2969	208	180	28	15.6%
chixN1	2970	213	184	29	15.8%
chixO1	2971	212	180	32	17.8%
chixP1	2964	213	180	33	18.3%
chixQ1	2924	206	206	0	0.0%
chixR1	2933	207	204	3	1.5%
chixS1	2914	209	206	3	1.5%
chixT1	2921	206	202	4	2.0%
chixU1	2928	206	202	4	2.0%
chixV1	2927	213	202	11	5.4%
chixW1	2920	210	208	2	1.0%
chixX1	2933	210	204	6	2.9%
chixY1	2973	200	188	12	6.4%
chixZ1	2980	189	178	11	6.2%

Beef Patties in Brine

Tray ID	Gross Wt.	Gas Est.	Gas cc	Diff cc	Diff %
beefpatA1	2620	302	292	10	3.4%
beefpatB1	2628	323	306	17	5.6%
beefpatC1	2674	323	294	29	9.9%
beefpatD1	2733	295	275	20	7.3%
beefpatE1	2760	292	265	27	10.2%
beefpatF1	2757	303	275	28	10.2%
beefpatG1	2799	268	250	18	7.2%
beefpatH1	2754	293	270	23	8.5%
beefpatI1	2709	290	290	0	0.0%
beefpatJ1	2700	301	290	11	3.8%
beefpatK1	2700	302	280	22	7.9%
beefpatL1	2710	320	300	20	6.7%
beefpatM1	2749	298	275	23	8.4%
beefpatN1	2735	320	300	20	6.7%
beefpatO1	2739	322	295	27	9.2%
beefpatP1	2713	304	280	24	8.6%
beefpatQ1	2710	313	305	8	2.6%
beefpatR1	2732	289	270	19	7.0%
beefpatS1	2722	288	270	18	6.7%
beefpatT1	2743	294	280	14	5.0%
beefpatV1	2747	307	280	27	9.6%
beefpatW1	2741	296	265	31	11.7%
beefpatX1	2772	312	280	32	11.4%
beefpatY1	2658	314	290	24	8.3%
beefpatZ1	2689	329	300	29	9.7%

Beef Hash

Tray ID	Gross Wt.	Gas Est.	Gas cc	Diff cc	Diff %
beefhashA1	2670	208	200	8	4.0%
beefhashB1	2753	212	200	12	6.0%
beefhashC1	2679	223	210	13	6.2%
beefhashD1	2786	228	215	13	6.0%
beefhashE1	2701	212	190	22	11.6%
beefhashF1	2690	215	200	15	7.5%
beefhashG1	2690	221	200	21	10.5%
beefhashH1	2690	202	185	17	9.2%
beefhashI1	2668	228	220	8	3.6%
beefhashJ1	2655	264	260	4	1.5%
beefhashK1	2736	218	205	13	6.3%
beefhashL1	2678	233	225	8	3.6%
beefhashM1	2700	125	120	5	4.2%
beefhashN1	2683	125	125	0	0.0%
beefhashP2	2696	133	120	13	10.8%
beefhashQ1	2694	136	125	11	8.8%
beefhashR1	2691	149	130	19	14.6%
beefhashS1	2712	136	110	26	23.6%
beefhashT1	2690	152	125	27	21.6%
beefhashU2	2681	172	145	27	18.6%
beefhashV1	2670	155	134	21	15.7%
beefhashW1	2682	146	120	26	21.7%
beefhashX1	2712	146	125	21	16.8%
beefhashY1	2683	217	190	27	14.2%

Potatoes w/Bacon

Gross Wt.	Gas Est.	Gas cc	Diff cc	Diff %
2970	137	130	7	5.4%
2959	146	130	16	12.3%
2961	132	120	12	10.0%
2908	164	145	19	13.1%
2943	145	140	5	3.6%
2944	131	130	1	0.8%
2963	137	120	17	14.2%
2951	125	110	15	13.6%
2964	146	135	11	8.1%
2966	125	110	15	13.6%
2963	130	130	0	0.0%
2957	132	125	7	5.6%
2972	138	120	18	15.0%
2963	121	110	11	10.0%
2963	132	125	7	5.6%
2964	136	135	1	0.7%
2963	150	130	20	15.4%
2958	143	130	13	10.0%
2965	150	135	15	11.1%
2968	131	115	16	13.9%
2956	125	110	15	13.6%
2954	141	120	21	17.5%
2953	131	115	16	13.9%
2958	138	125	13	10.4%
2938	142	125	17	13.6%

ITR Performance Summary

Performance Goal -0%+20%

	No Regression, Direct Offset, Deviation %		
	Lowest Underest	Avg % Dev	Highest Overest.
CCMein	0%	+12.6%	+24.3%
BeefPat	0%	+7.4%	+11.7%
BeefHash	0%	+10.3%	+23.6%
PotatBac	0%	+10.0%	+17.5%
	No Regression, Direct Offset, cc Deviation		
	Lowest Underest	Avg cc Dev	Highest Overest.
CCMein	0cc	+22cc	+39cc
BeefPat	0cc	+21cc	+32cc
BeefHash	0cc	+16cc	+27cc
PotatBac	0cc	+12cc	+21cc

	Regression Compensated, Offset, Deviation %		
	Lowest Underest	Avg % Dev	Highest Overest.
CCMein	0.0%	+8.2%	+16.5%
BeefPat	0.0%	+5.4%	+9.8%
BeefHash	0.0%	+11.3%	+23.6%
PotatBac	0.0%	+9.2%	+15.9%
	Regression Compensated, Offset, cc Deviation		
	Lowest Underest	Avg cc Dev	Highest Overest.
CCMein	0cc	+15cc	+22cc
BeefPat	0cc	+15cc	+25cc
BeefHash	0cc	+18cc	+29cc
PotatBac	0cc	+11cc	+19cc

QA Residual Gas Measurement Conclusions

- Unit performance met performance goal of measuring on average within -0%+20% of destruct measurements.
- Outlying data points out of specification would not represent an operational issue since headspaces for these trays were substantially below the current limit of 250cc.
- A test run of 25+ trays is recommended for each new product to determine offsets of direct measurements.
- If additional accuracy is necessary, regression analysis using weight can be applied.

IPR Discussion Notes

- Retorting regulations require in process headspace measurement and monitoring
- End item residual gas testing is redundant since in-process records already contain gas data
- End item inspection should be phased out
- Could the unit be used for regulatory compliance?
- Industry offered +-5cc as target for acceptance / replacement of destruct method

Progress Since ITR

- Experiments to simulate adjustable height were run using multiple shim plates
- Accuracy improved on products tested
- Increasing pre-test vacuum time from 75 to 120 seconds improved repeatability and improved accuracy
- Repeatability remains the most significant issue to reaching +-5cc accuracy
  - Measurement variation alone in 20 tests of Potatoes with Bacon was +-5cc
  - Beef patty variation for 20 tests was +-4cc

Next Steps

- Solicit addition input from partners on system improvement
  - Apply and test improvements
  - Report results
- Submit Final Technical Report
- Ship unit back to supplier
- Provide support of unit if requested under STP2001

Appendix 4.2.1 PTI-USA Evaluation Experimental Data

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.288675
R Square	0.083333
Adjusted R	-0.375
Standard E	0.033166
Observatio	4

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	0.0002	0.0002	0.181818	0.711325
Residual	2	0.0022	0.0011		
Total	3	0.0024			

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	3.66	5.511263	0.664095	0.574946	-20.05307	27.37307	-20.05307	27.37307
X Variable	-0.01	0.023452	-0.426401	0.711325	-0.110906	0.090906	-0.110906	0.090906

RESIDUAL OUTPUT

Observatior	*Predicted Y*	*Residuals*	*ıdard Residuals*
1	1.31	0.04	1.477098
2	1.3	-0.01	-0.369274
3	1.32	-0.01	-0.369274
4	1.31	-0.02	-0.738549

PROBABILITY OUTPUT

Percentile	*Y*
12.5	1.29
37.5	1.29
62.5	1.31
87.5	1.35

Appendix 4.2.1 PTI-USA Evaluation Experimental Data

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.983739
R Square	0.967742
Adjusted R	0.951613
Standard E	0.007906
Observatio	4

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	0.00375	0.00375	60	0.016261
Residual	2	0.000125	6.25E-05		
Total	3	0.003875			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	2.84	0.211437	13.43188	0.005497	1.930258	3.749742	1.930258	3.749742
X Variable	-1.25	0.161374	-7.745967	0.016261	-1.944338	-0.555662	-1.944338	-0.555662

RESIDUAL OUTPUT

Observatior	*Predicted Y*	*Residuals*	*dard Residuals*
1	1.1525	-0.0025	-0.387298
2	1.2275	-0.0075	-1.161895
3	1.2025	0.0075	1.161895
4	1.2275	0.0025	0.387298

PROBABILITY OUTPUT

Percentile	*Y*
12.5	1.15
37.5	1.21
62.5	1.22
87.5	1.23

Appendix 4.2.1 PTI-USA Evaluation Experimental Data

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.951805778
R Square	0.905934238
Adjusted R	0.899215255
Standard E	0.036838385
Observatio	16

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	0.182976	0.182976	134.832	1.43E-08
Residual	14	0.018999	0.001357		
Total	15	0.201975			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	0.852528634	0.014578	58.47967	3.93E-18	0.821261	0.883796	0.821261	0.883796
X Variable	0.000829203	7.14E-05	11.61172	1.43E-08	0.000676	0.000982	0.000676	0.000982

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*	*dard Residuals*
1	0.852528634	-0.032529	-0.914001
2	0.959495814	0.000504	0.014167
3	0.852528634	0.027471	0.7719
4	1.159333724	0.030666	0.861672
5	1.043245311	-0.003245	-0.091188
6	1.072267414	0.007733	0.217273
7	0.852528634	-0.042529	-1.194985
8	1.058170964	-0.068171	-1.915493
9	0.898963999	0.011036	0.310094
10	0.903939217	0.076061	2.137184
11	1.073096617	-0.043097	-1.210944
12	1.018369223	-0.018369	-0.516145
13	0.905597622	0.014402	0.404683
14	1.102947923	0.037052	1.041103
15	1.134457635	0.005542	0.155731
16	0.852528634	-0.002529	-0.07105

PROBABILITY OUTPUT

Percentile	*Y*
3.125	0.81
9.375	0.82
15.625	0.85
21.875	0.88
28.125	0.91
34.375	0.92
40.625	0.96
46.875	0.98
53.125	0.99
59.375	1
65.625	1.03
71.875	1.04
78.125	1.08
84.375	1.14
90.625	1.14
96.875	1.19

Appendix 4.2.1 PTI-USA Evaluation Experimental Data

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.951806
R Square	0.905934
Adjusted R	0.899215
Standard E	42.28517
Observatio	16

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	241084.5	241084.5	134.832	1.43E-08
Residual	14	25032.5	1788.036		
Total	15	266117			

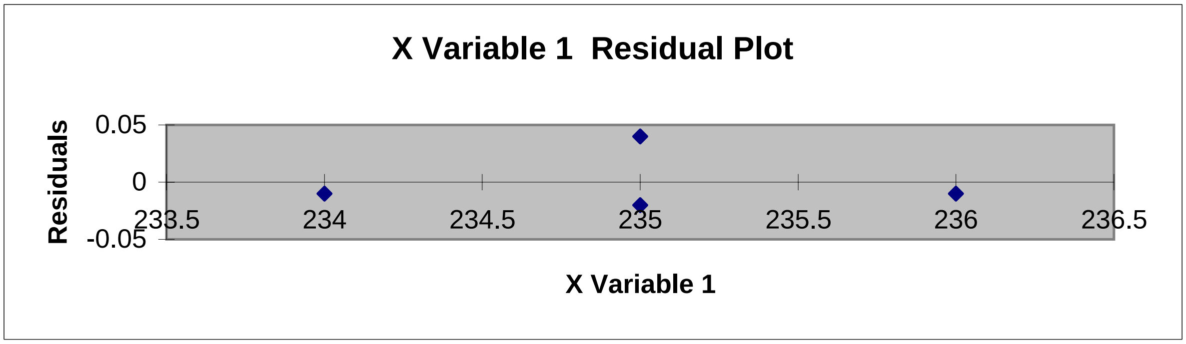
	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	-916.5325	93.16186	-9.838066	1.14E-07	-1116.345	-716.72	-1116.345	-716.72
X Variable	1092.536	94.08909	11.61172	1.43E-08	890.735	1294.337	890.735	1294.337

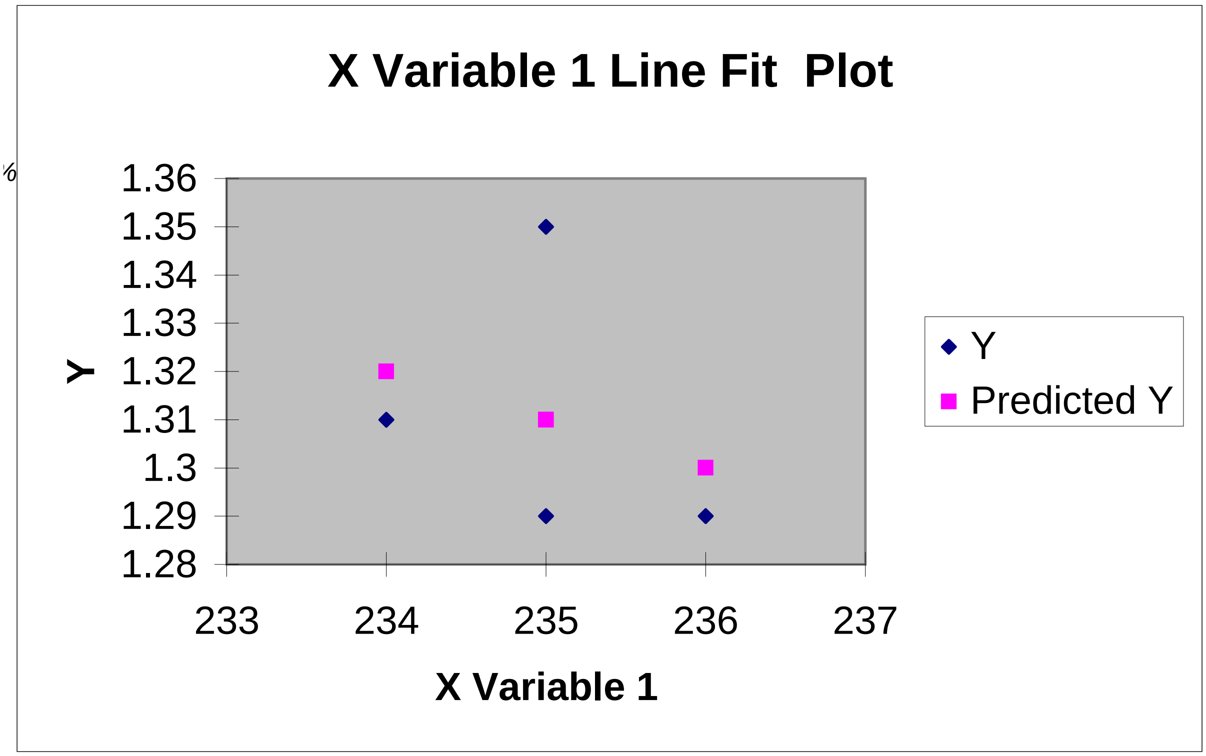
RESIDUAL OUTPUT

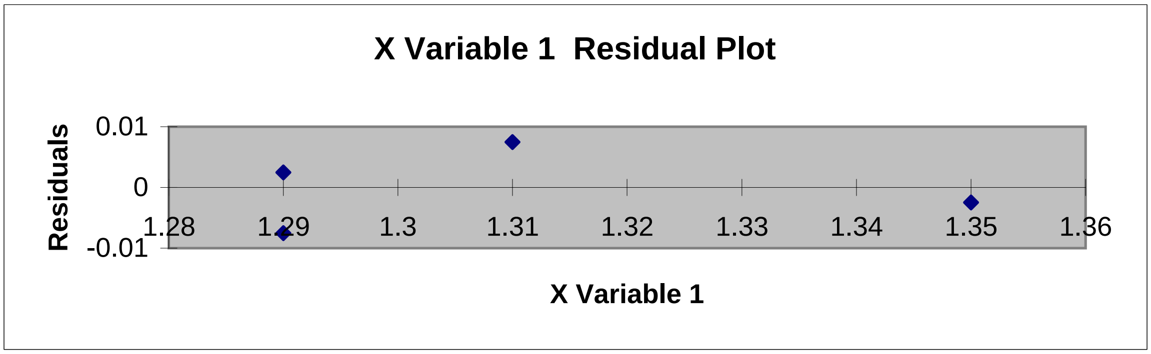
Observation	*Predicted Y*	*Residuals*	*dard Residuals*
1	-20.6528	20.6528	0.50556
2	132.3023	-3.302265	-0.080836
3	44.89937	-44.89937	-1.099091
4	383.5856	-13.58559	-0.332562
5	219.7052	10.29484	0.252007
6	263.4066	1.59339	0.039005
7	-31.57817	31.57817	0.773002
8	165.0784	82.92165	2.029838
9	77.67545	-21.67545	-0.530593
10	154.153	-92.15299	-2.255812
11	208.7798	57.2202	1.400693
12	176.0037	23.99629	0.587405
13	88.60082	-24.60082	-0.602203
14	328.9588	-26.95878	-0.659924
15	328.9588	11.04122	0.270278
16	12.12328	-12.12328	-0.296766

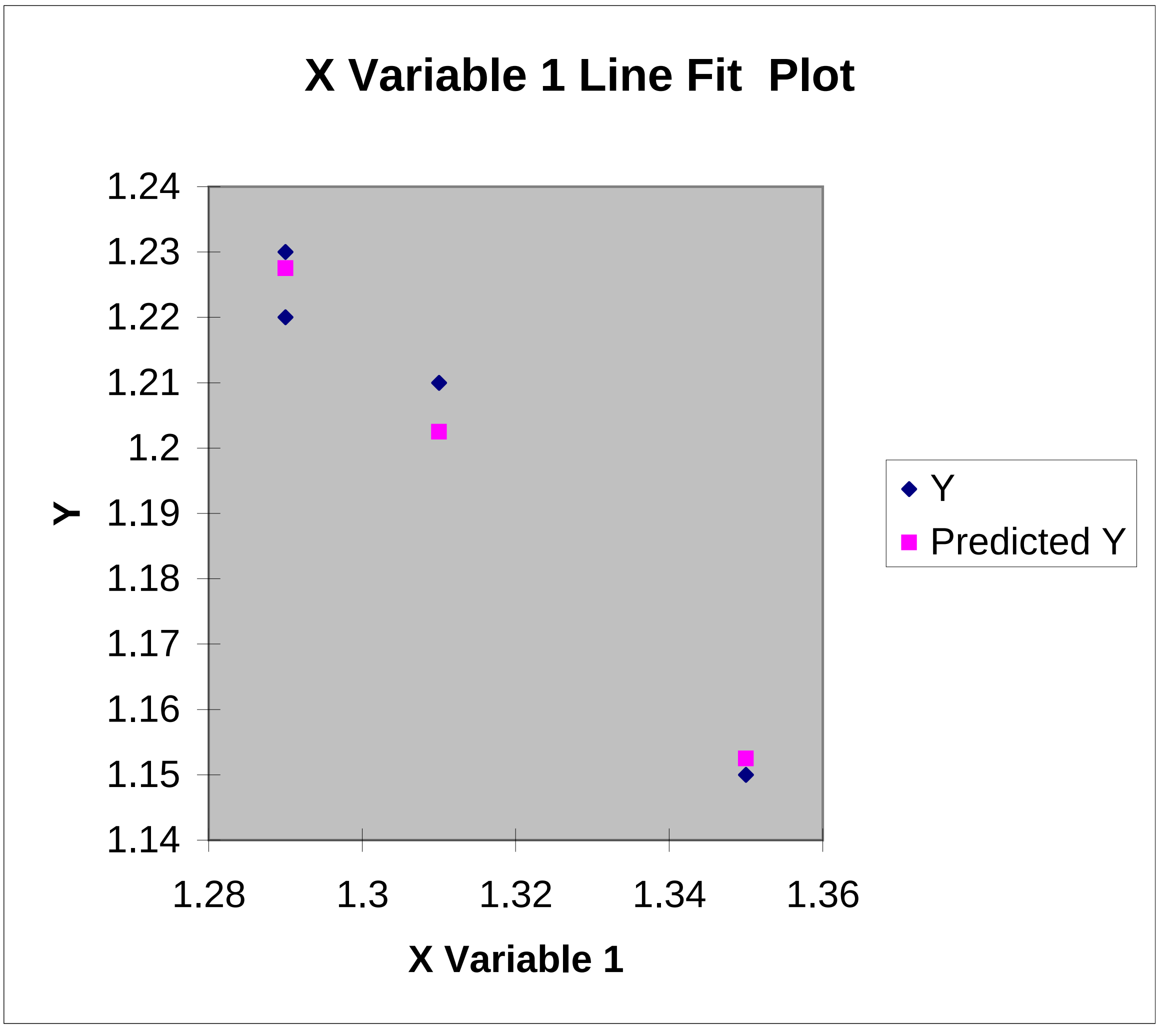
PROBABILITY OUTPUT

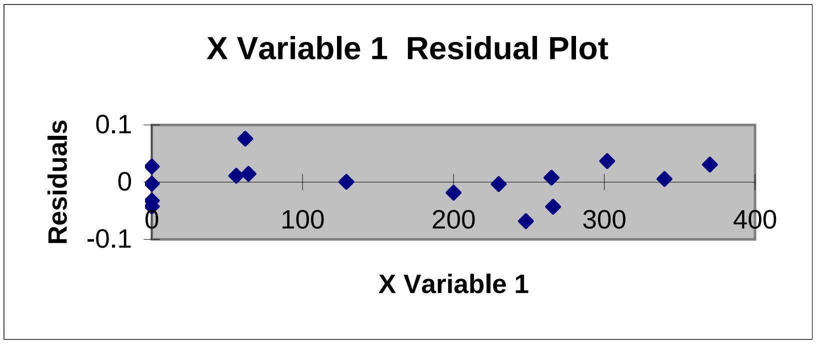
Percentile	*Y*
3.125	0
9.375	0
15.625	0
21.875	0
28.125	56
34.375	62
40.625	64
46.875	129
53.125	200
59.375	230
65.625	248
71.875	265
78.125	266
84.375	302
90.625	340
96.875	370

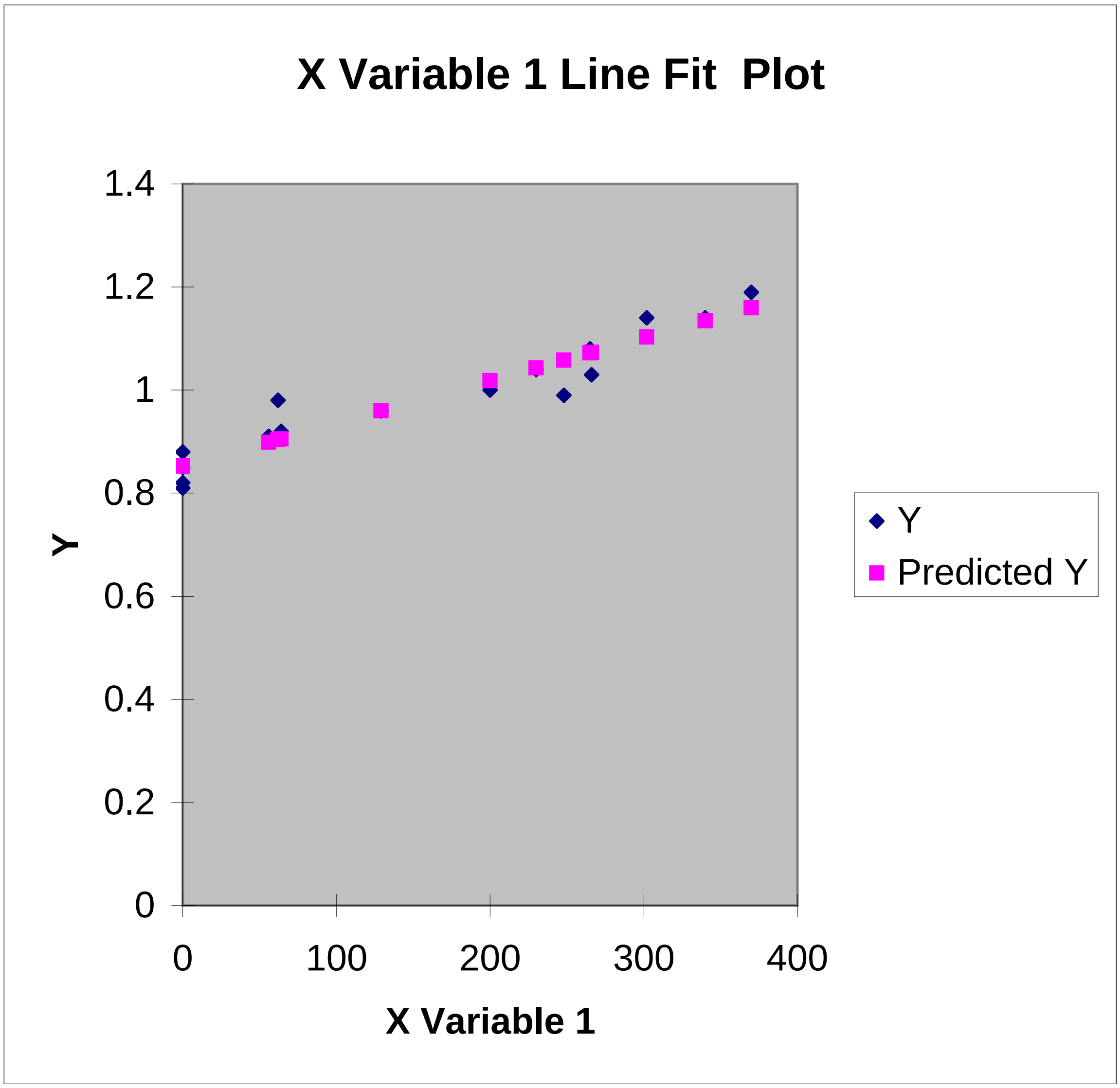

X Variable 1 Residual Plot
Residuals
0.05
0
-0.05
233.5
234
234.5
235
235.5
236
236.5
X Variable 1

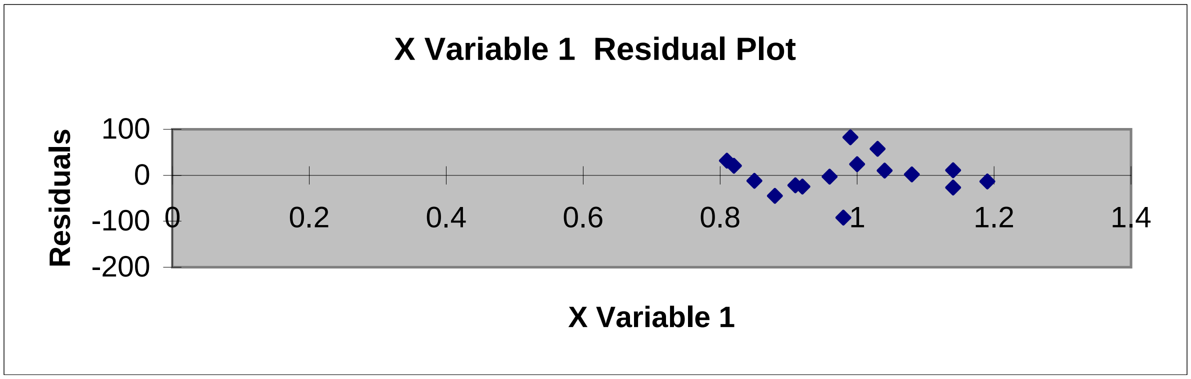

X Variable 1 Line Fit Plot
Y
1.36
1.35
1.34
1.33
1.32
1.31
1.3
1.29
1.28
233
234
235
236
237
X Variable 1
Y
Predicted Y

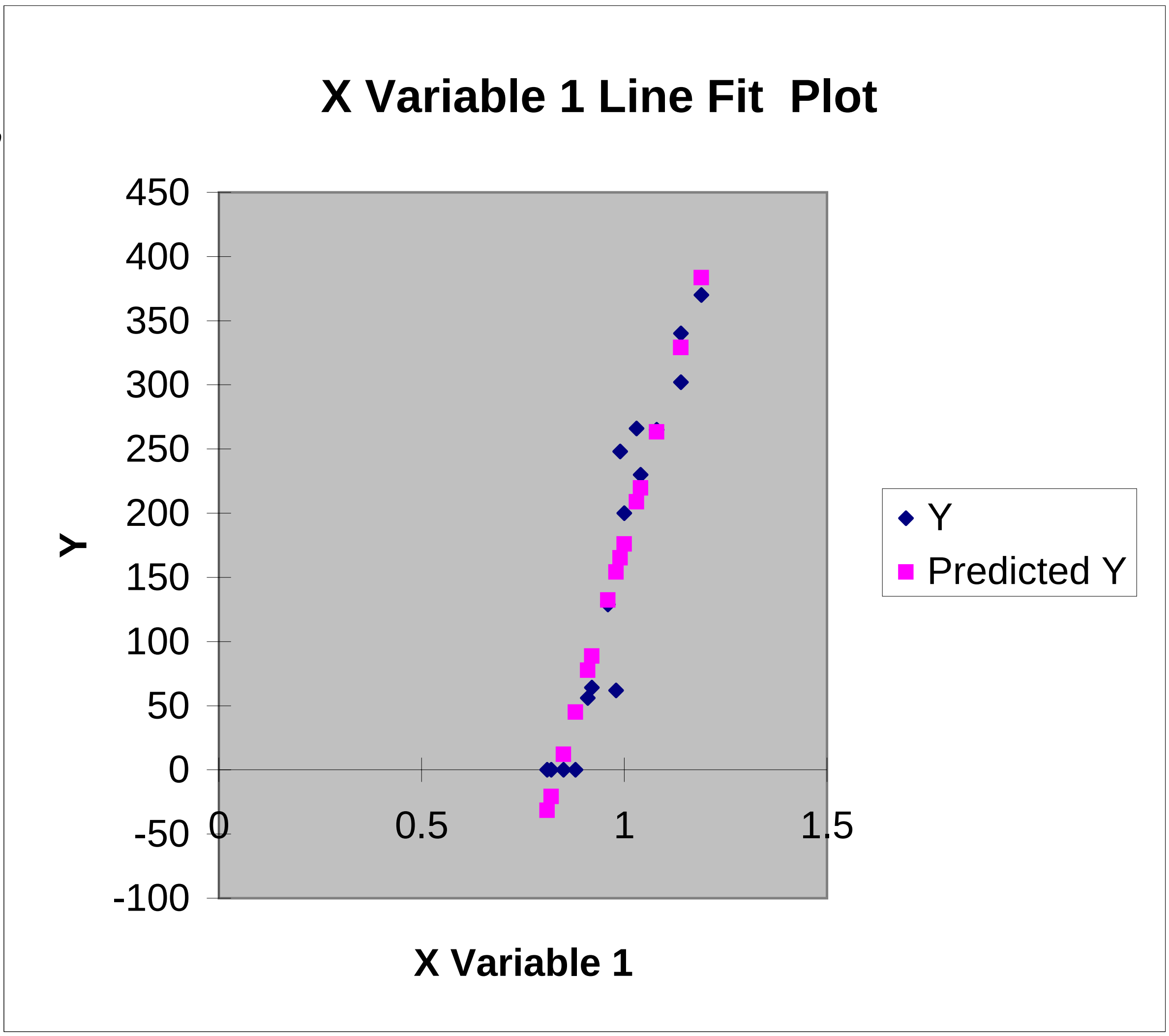

X Variable 1 Residual Plot
Residuals
0.01
0
-0.01
1.28
1.29
1.3
1.31
1.32
1.33
1.34
1.35
1.36
X Variable 1


X Variable 1 Line Fit Plot
Y
1.24
1.23
1.22
1.21
1.2
1.19
1.18
1.17
1.16
1.15
1.14
1.28
1.3
1.32
1.34
1.36
X Variable 1
Y
Predicted Y


X Variable 1 Residual Plot
Residuals
0.1
0
-0.1
0
100
200
300
400
X Variable 1


X Variable 1 Line Fit Plot
Y
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
100
200
300
400
X Variable 1
Y
Predicted Y

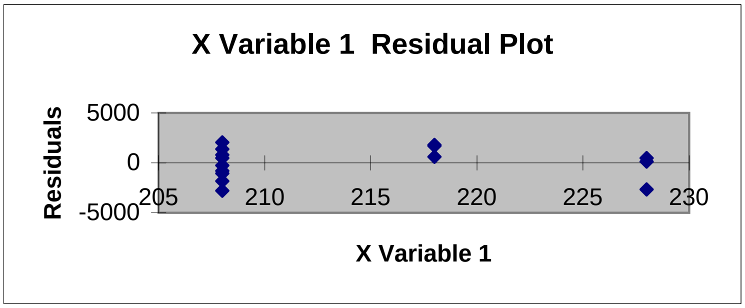

X Variable 1 Residual Plot
Residuals
100
0
-100
-200
0
0.2
0.4
0.6
0.8
1
1.2
1.4
X Variable 1

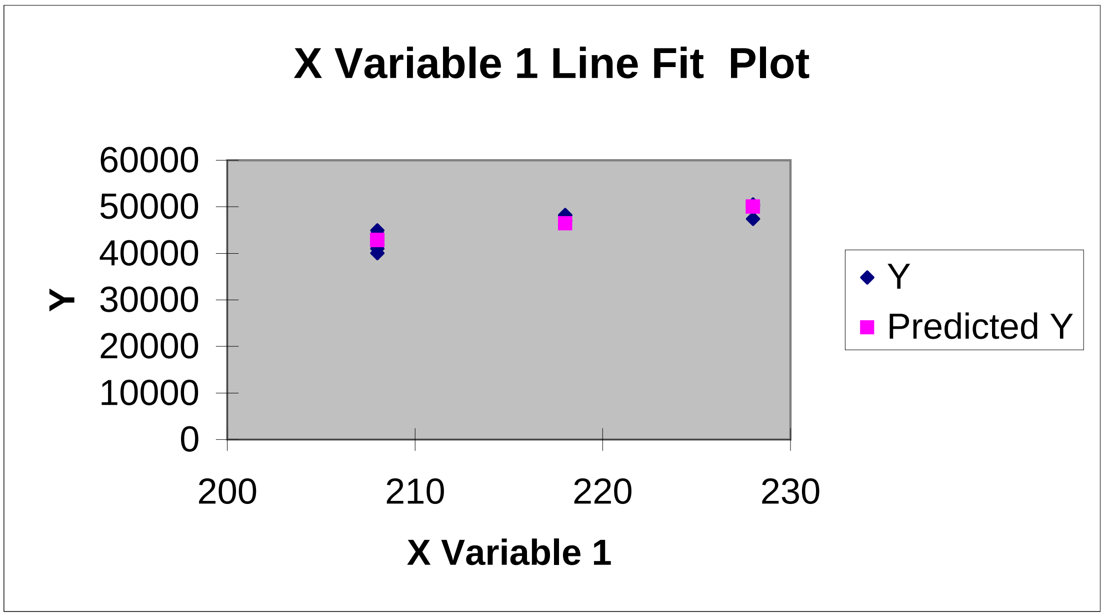

X Variable 1 Line Fit Plot
Y
450
400
350
300
250
200
150
100
50
0
-50
-100
0
0.5
1
1.5
X Variable 1
Y
Predicted Y

Appendix 4.2.1 PTI-USA Evaluation Experimental Data

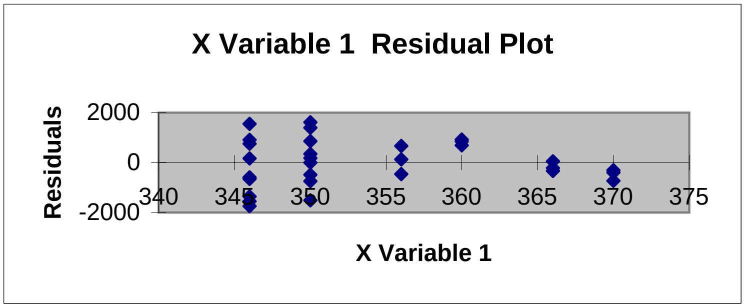
Product	Tray #	Weight g	Res Gas cc	test 1	test 2	test 3	test 4	min	avg
Pork Sausage	1	2741	235	1.35	1.35	1.35		1.35	1.35
	2	2742	236	1.33	1.29	1.32		1.29	1.313333
	3	2754	234	1.33	1.31	1.32		1.31	1.32
	4	2757	235	1.29	1.3	1.3		1.29	1.296667
Turkey Slices	1	2987	132	1.18	1.17	1.15		1.15	1.166667
	2	2944	150	1.28	1.22	1.25		1.22	1.25
	3	2977	142	1.22	1.23	1.21		1.21	1.22
	4	2953	170	1.25	1.26	1.23		1.23	1.246667
Water	1	3091	0	1	0.9	0.82	0.86	0.82	0.895
	2	2906	129	1.12	1.02	0.96	1.16	0.96	1.065
	3	3002	0	0.93	0.88	0.91	0.92	0.88	0.91
	4	2700	370	1.29	1.19	1.22	1.2	1.19	1.225
	5	2800	230	1.04	1.04	1.06	1.05	1.04	1.0475
	6	2749	265	1.11	1.08	1.12	1.09	1.08	1.1
	7	3101	0	0.86	0.81	0.81	0.82	0.81	0.825
	8	2847	248	1.05	1.01	0.99	1.02	0.99	1.0175
	9	2946	56	1.01	0.92	0.92	0.91	0.91	0.94
	10	2897	62	1.09	1	0.98	0.98	0.98	1.0125
	11	2800	266	1.04	1.03	1.06	1.05	1.03	1.045
	12	2847	200	1.01	1	1.01	1	1	1.005
	13	2947	64	0.98	0.92	0.92	0.92	0.92	0.935
	14	2698	302	1.15	1.14	1.14	1.17	1.14	1.15
	15	2695	340	1.2	1.14	1.15	1.16	1.14	1.1625
	16	3042	0	0.88	0.86	0.85	0.85	0.85	0.86
		2879.25							

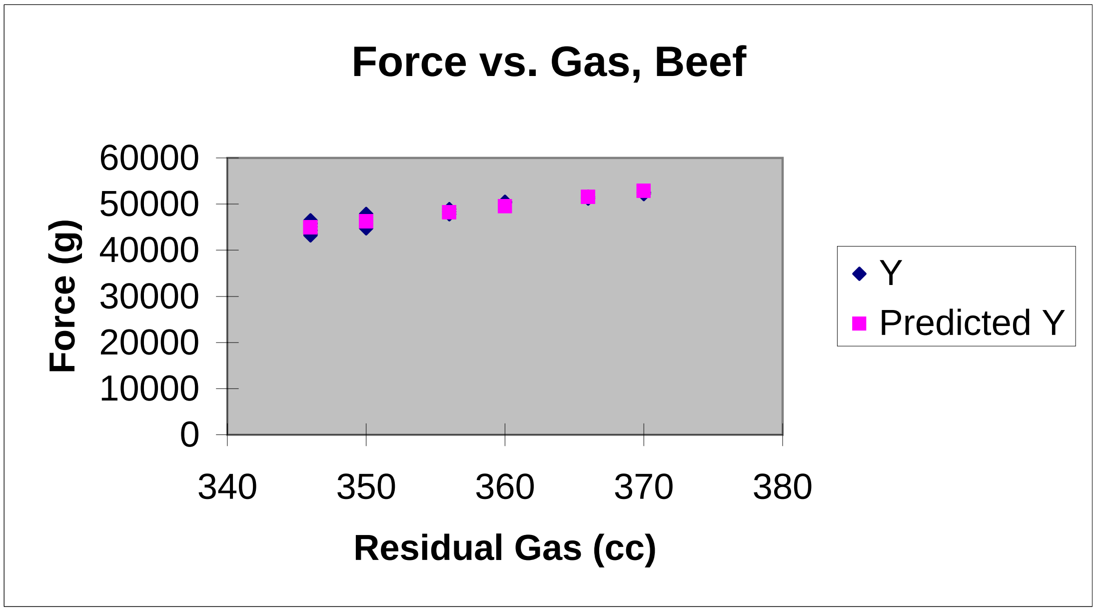
Product	Tray #	%dev	raw calc.	%dev.vs.min	Calc w/wt		Calc gas	%off from gas			
Pork Sausage	1	0.00%	1.047391						Pork		
	2	1.81%	1.048221						Pork		
	3	0.76%	1.046562						Pork		
	4	0.52%	1.047391						Pork		
Turkey Slices	1	1.45%	0.961983						CrmBeef		
	2	2.46%	0.976909						CrmBeef		
	3	0.83%	0.970275						CrmBeef		
	4	1.36%	0.993493						CrmBeef		
Water	1	9.15%	0.852529	3.97%	0.823327	0.41%	0	0.00%	Water	-20.6528	0.00%
	2	10.94%	0.959496	-0.05%	0.955572	-0.46%	129.608	0.47%	Water	132.3023	2.56%
	3	3.41%	0.852529	-3.12%	0.835099	-5.10%	0	0.00%	Water	44.89937	0.00%
	4	2.94%	1.159334	-2.58%	1.187633	-0.20%	406.9828	10.00%	Water	383.5856	3.67%
	5	0.72%	1.043245	0.31%	1.05531	1.47%	226.0862	1.70%	Water	219.7052	4.48%
	6	1.85%	1.072267	-0.72%	1.092464	1.15%	274.3253	3.52%	Water	263.4066	0.60%
	7	1.85%	0.852529	5.25%	0.822047	1.49%	0	0.00%	Water	-31.57817	0.00%
	8	2.78%	1.058171	6.89%	1.063	7.37%	165.7874	33.15%	Water	165.0784	33.44%
	9	3.30%	0.898964	-1.21%	0.889306	-2.27%	69.30917	23.77%	Water	77.67545	38.71%
	10	3.32%	0.903939	-7.76%	0.901327	-8.03%	153.7276	147.95%	Water	154.153	148.63%
	11	1.46%	1.073097	4.18%	1.085161	5.36%	214.0265	19.54%	Water	208.7798	21.51%
	12	0.50%	1.018369	1.84%	1.023198	2.32%	177.8471	11.08%	Water	176.0037	12.00%
	13	1.63%	0.905598	-1.57%	0.895798	-2.63%	81.36894	27.14%	Water	88.60082	38.44%
	14	0.88%	1.102948	-3.25%	1.131584	-0.74%	346.684	14.80%	Water	328.9588	8.93%
	15	1.97%	1.134458	-0.49%	1.1636	2.07%	346.684	1.97%	Water	328.9588	3.25%
	16	1.18%	0.852529	0.30%	0.829723	-2.39%	0	0.00%	Water	12.12328	0.00%
							AVG DEV	18.44%			19.76%
							MAX DEV	147.95%			148.63%


X Variable 1 Residual Plot
Residuals
5000
0
-5000
205
210
215
220
225
230
X Variable 1


X Variable 1 Line Fit Plot
Y
60000
50000
40000
30000
20000
10000
0
200
210
220
230
X Variable 1
Y
Predicted Y

Appendix 4.2.2 Precision Automation Evaluation Experimental Data - Beef





Appendix 4.2.2 Precision Automation Evaluation Experimental Data - Beef

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.886132
R Square	0.78523
Adjusted R Sq	0.768709
Standard Erro	1612.709
Observations	15

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	1	1.24E+08	1.24E+08	47.52988	1.09E-05
Residual	13	33810801	2600831		
Total	14	1.57E+08			

	Coefficients	*tandard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Upper 95.0%*
Intercept	-31783.2	11146.47	-2.851413	0.01362	-55863.69	-7702.716	-55863.69	-7702.716
X Variable 1	358.8424	52.04996	6.894192	1.09E-05	246.3953	471.2895	246.3953	471.289529

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*	*dard Residuals*
1	42856.03	-1066.025	-0.685968
2	42856.03	-812.4316	-0.522785
3	42856.03	-2798.572	-1.80083
4	42856.03	786.8614	0.506331
5	42856.03	476.795	0.306809
6	42856.03	-1832.643	-1.179272
7	42856.03	2065.963	1.32941
8	42856.03	1378.389	0.886968
9	42856.03	-245.7323	-0.158124
10	46444.45	1688.371	1.086436
11	46444.45	596.9722	0.384141
12	46444.45	1809.449	1.164347
13	50032.87	126.3329	0.081293
14	50032.87	-2650.378	-1.70547
15	50032.87	476.6493	0.306715

Appendix 4.2.2 Precision Automation Evaluation Experimental Data - Beef

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.94993
R Square	0.902367
Adjusted R S	0.89888
Standard Err	926.6835
Observations	30

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	1	2.22E+08	2.22E+08	258.7889	1.12E-15
Residual	28	24044783	858742.3		
Total	29	2.46E+08			

	Coefficients	*tandard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Upper 95.0%*
Intercept	-69262.15	7265.03	-9.533636	2.73E-10	-84143.91	-54380.39	-84143.91	-54380.395
X Variable 1	330.0571	20.51712	16.08692	1.12E-15	288.0297	372.0846	288.0297	372.08459

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*	*dard Residuals*
1	44937.62	-1547.348	-1.699325
2	44937.62	-1740.723	-1.911693
3	44937.62	-1361.36	-1.49507
4	44937.62	-650.2385	-0.714104
5	44937.62	172.2146	0.189129
6	44937.62	-586.8127	-0.644448
7	44937.62	904.2888	0.993106
8	44937.62	1549.086	1.701234
9	44937.62	751.3943	0.825195
10	48238.19	129.4675	0.142184
11	48238.19	665.4636	0.730824
12	48238.19	-462.7004	-0.508146
13	51538.76	-332.4515	-0.365104
14	51538.76	52.34155	0.057482
15	51538.76	-220.9554	-0.242657
16	46257.85	-1507.639	-1.655716
17	46257.85	-493.3303	-0.541784
18	46257.85	-746.3186	-0.819621
19	46257.85	5.693158	0.006252
20	46257.85	346.9666	0.381045
21	46257.85	174.2713	0.191388
22	46257.85	1617.33	1.776181
23	46257.85	1393.592	1.530467
24	46257.85	854.0525	0.937936
25	49558.42	845.3796	0.928411
26	49558.42	927.321	1.018401
27	49558.42	696.1647	0.764541
28	52858.99	-310.7933	-0.341319
29	52858.99	-725.2425	-0.796474
30	52858.99	-399.1136	-0.438314

Appendix 4.2.2 Precision Automation Evaluation Experimental Data - Beef

Gross Forc	Res Gas	gross wt	Vacuum	Calc gas	% diff	
41790	208	2808	790.2104			
42043.59	208	2808	789.6594			
40057.45	208	2808	778.7068			
43642.89	208	2818	789.6899			
43332.82	208	2818	789.9924			
41023.38	208	2818	778.4988			
44921.99	208	2828	790.4841			
44234.41	208	2828	791.0829			
42610.29	208	2828	778.8512			
48132.82	218	2828	790.5427			
47041.42	218	2828	789.7505			
48253.9	218	2828	790.2623			
50159.21	228	2828	790.3201			
47382.5	228	2828	778.0557			
50509.52	228	2828	789.8091			
43390.27	346	2803	686.0816	341.3119	1.35%	1.35%
43196.89	346	2803	685.6561	340.726	1.52%	1.52%
43576.26	346	2803	686.7604	341.8754	1.19%	1.19%
44287.38	346	2813	685.2832	344.0299	0.57%	0.57%
45109.83	346	2813	686.026	346.5218	-0.15%	0.15%
44350.8	346	2813	686.0963	344.2221	0.51%	0.51%
45841.91	346	2823	685.7389	348.7398	-0.79%	0.79%
46486.7	346	2823	688.304	350.6934	-1.36%	1.36%
45689.01	346	2823	686.2042	348.2766	-0.66%	0.66%
48367.66	356	2823	687.4064	356.3923	-0.11%	0.11%
48903.65	356	2823	686.0168	358.0162	-0.57%	0.57%
47775.49	356	2823	685.3452	354.5981	0.39%	0.39%
51206.31	366	2823	685.6745	364.9927	0.28%	0.28%
51591.1	366	2823	685.4518	366.1586	-0.04%	0.04%
51317.8	366	2823	686.454	365.3306	0.18%	0.18%
44750.21	350	2773	686.4993	345.4322	1.31%	1.31%
45764.52	350	2773	686.293	348.5053	0.43%	0.43%
45511.53	350	2773	686.0984	347.7388	0.65%	0.65%
46263.54	350	2783	686.5386	350.0172	0.00%	0.00%
46604.81	350	2783	685.631	351.0512	-0.30%	0.30%
46432.12	350	2783	685.6331	350.528	-0.15%	0.15%
47875.18	350	2793	686.5089	354.9002	-1.40%	1.40%
47651.44	350	2793	685.4431	354.2223	-1.21%	1.21%
47111.9	350	2793	685.3661	352.5876	-0.74%	0.74%
50403.8	360	2793	686.6566	362.5613	-0.71%	0.71%
50485.74	360	2793	685.8808	362.8096	-0.78%	0.78%
50254.58	360	2793	686.9976	362.1092	-0.59%	0.59%
52548.2	370	2793	685.936	369.0584	0.25%	0.25%
52133.75	370	2793	685.2305	367.8027	0.59%	0.59%
52459.88	370	2793	685.3234	368.7908	0.33%	0.33%
					-1.40%	0.64%
					1.52%	

Appendix 4.2.2 Precision Automation Evaluation Experimental Data - Pork

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.916298
R Square	0.839602
Adjusted R	0.833874
Standard E	1564.502
Observatio	30

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	3.59E+08	3.59E+08	146.5661	1.21E-12
Residual	28	68534625	2447665		
Total	29	4.27E+08			

	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	-47674.44	7661.106	-6.222918	1.01E-06	-63367.52	-31981.35	-63367.52	-31981.35
X Variable	404.735	33.43135	12.10645	1.21E-12	336.2539	473.2161	336.2539	473.2161

RESIDUAL OUTPUT

Observatior	*Predicted Y*	*Residuals*	*dard Residuals*
1	41367.26	-1061.34	-0.690396
2	41367.26	-986.512	-0.641721
3	41367.26	-1282.614	-0.834334
4	41367.26	130.9958	0.085212
5	41367.26	-136.2972	-0.088661
6	41367.26	-2343.746	-1.524595
7	41367.26	1028.035	0.668732
8	41367.26	770.4958	0.501204
9	41367.26	928.8513	0.604213
10	45414.61	-286.6273	-0.18645
11	45414.61	-401.6664	-0.261282
12	45414.61	-2480.651	-1.613651
13	49461.96	-909.3949	-0.591557
14	49461.96	-1198.446	-0.779583
15	49461.96	-3638.844	-2.36705
16	43795.67	-1790.668	-1.164821
17	43795.67	569.6094	0.370528
18	43795.67	405.3477	0.263677
19	43795.67	-1224.07	-0.796252
20	43795.67	1543.129	1.003798
21	43795.67	1602.707	1.042553
22	43795.67	2580.074	1.678326
23	43795.67	2914.164	1.895649
24	43795.67	-908.0976	-0.590713
25	47843.02	1694.873	1.102506
26	47843.02	1748.615	1.137466
27	47843.02	1365.982	0.888565
28	51890.37	885.7811	0.576196
29	51890.37	112.246	0.073015
30	51890.37	368.0663	0.239425

PROBABILITY OUTPUT

Percentile	*Y*
1.666667	39023.51
5	40084.64
8.333333	40305.92
11.66667	40380.75
15	41230.96
18.33333	41498.25
21.66667	42005
25	42137.75
28.33333	42296.11
31.66667	42395.29
35	42571.6
38.33333	42887.57
41.66667	42933.96
45	44201.02
48.33333	44365.28
51.66667	45012.94
55	45127.98
58.33333	45338.8
61.66667	45398.38
65	45823.11
68.33333	46375.74
71.66667	46709.83
75	48263.51
78.33333	48552.56
81.66667	49209
85	49537.89
88.33333	49591.63
91.66667	52002.61
95	52258.43
98.33333	52776.15

Appendix 4.2.2 Precision Automation Evaluation Experimental Data - Pork

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.980541
R Square	0.96146
Adjusted R	0.958495
Standard E	725.3155
Observatio	15

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	1.71E+08	1.71E+08	324.3114	1.42E-10
Residual	13	6839074	526082.6		
Total	14	1.77E+08			

	Coefficients	*tandard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	-30818.73	3609.918	-8.53724	1.09E-06	-38617.49	-23019.98	-38617.49	-23019.98
X Variable	421.5727	23.40946	18.00865	1.42E-10	370.9996	472.1457	370.9996	472.1457

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*	*dard Residuals*
1	28201.44	11.2147	0.016045
2	28201.44	247.2674	0.353779
3	28201.44	238.2264	0.340844
4	32417.17	-538.8851	-0.771013
5	32417.17	-169.6448	-0.24272
6	32417.17	-284.887	-0.407604
7	36632.89	-938.5923	-1.342896
8	36632.89	-836.0025	-1.196115
9	36632.89	-1006.131	-1.439528
10	36632.89	42.25144	0.060451
11	36632.89	-104.772	-0.149903
12	36632.89	30.50924	0.043651
13	36632.89	1147.646	1.642001
14	36632.89	1255.669	1.796556
15	36632.89	906.1303	1.296451

PROBABILITY OUTPUT

Percentile	*Y*
3.333333	28212.65
10	28439.67
16.66667	28448.71
23.33333	31878.28
30	32132.28
36.66667	32247.52
43.33333	35626.76
50	35694.3
56.66667	35796.89
63.33333	36528.12
70	36663.4
76.66667	36675.14
83.33333	37539.02
90	37780.54
96.66667	37888.56

Appendix 4.2.2 Precision Automation Evaluation Experimental Data - Pork

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.916298
R Square	0.839602
Adjusted R	0.833874
Standard E	1564.502
Observatio	30

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	3.59E+08	3.59E+08	146.5661	1.21E-12
Residual	28	68534625	2447665		
Total	29	4.27E+08			

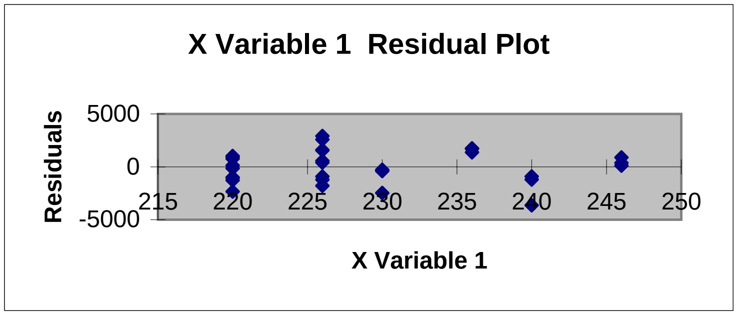
	Coefficients	*tandard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	-47674.44	7661.106	-6.222918	1.01E-06	-63367.52	-31981.35	-63367.52	-31981.35
X Variable	404.735	33.43135	12.10645	1.21E-12	336.2539	473.2161	336.2539	473.2161

RESIDUAL OUTPUT

Observatior	*Predicted Y*	*Residuals*	*ıdard Residuals*
1	41367.26	-1061.34	-0.690396
2	41367.26	-986.512	-0.641721
3	41367.26	-1282.614	-0.834334
4	41367.26	130.9958	0.085212
5	41367.26	-136.2972	-0.088661
6	41367.26	-2343.746	-1.524595
7	41367.26	1028.035	0.668732
8	41367.26	770.4958	0.501204
9	41367.26	928.8513	0.604213
10	45414.61	-286.6273	-0.18645
11	45414.61	-401.6664	-0.261282
12	45414.61	-2480.651	-1.613651
13	49461.96	-909.3949	-0.591557
14	49461.96	-1198.446	-0.779583
15	49461.96	-3638.844	-2.36705
16	43795.67	-1790.668	-1.164821
17	43795.67	569.6094	0.370528
18	43795.67	405.3477	0.263677
19	43795.67	-1224.07	-0.796252
20	43795.67	1543.129	1.003798
21	43795.67	1602.707	1.042553
22	43795.67	2580.074	1.678326
23	43795.67	2914.164	1.895649
24	43795.67	-908.0976	-0.590713
25	47843.02	1694.873	1.102506
26	47843.02	1748.615	1.137466
27	47843.02	1365.982	0.888565
28	51890.37	885.7811	0.576196
29	51890.37	112.246	0.073015
30	51890.37	368.0663	0.239425

PROBABILITY OUTPUT

Percentile	*Y*
1.666667	39023.51
5	40084.64
8.333333	40305.92
11.66667	40380.75
15	41230.96
18.33333	41498.25
21.66667	42005
25	42137.75
28.33333	42296.11
31.66667	42395.29
35	42571.6
38.33333	42887.57
41.66667	42933.96
45	44201.02
48.33333	44365.28
51.66667	45012.94
55	45127.98
58.33333	45338.8
61.66667	45398.38
65	45823.11
68.33333	46375.74
71.66667	46709.83
75	48263.51
78.33333	48552.56
81.66667	49209
85	49537.89
88.33333	49591.63
91.66667	52002.61
95	52258.43
98.33333	52776.15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Residuals
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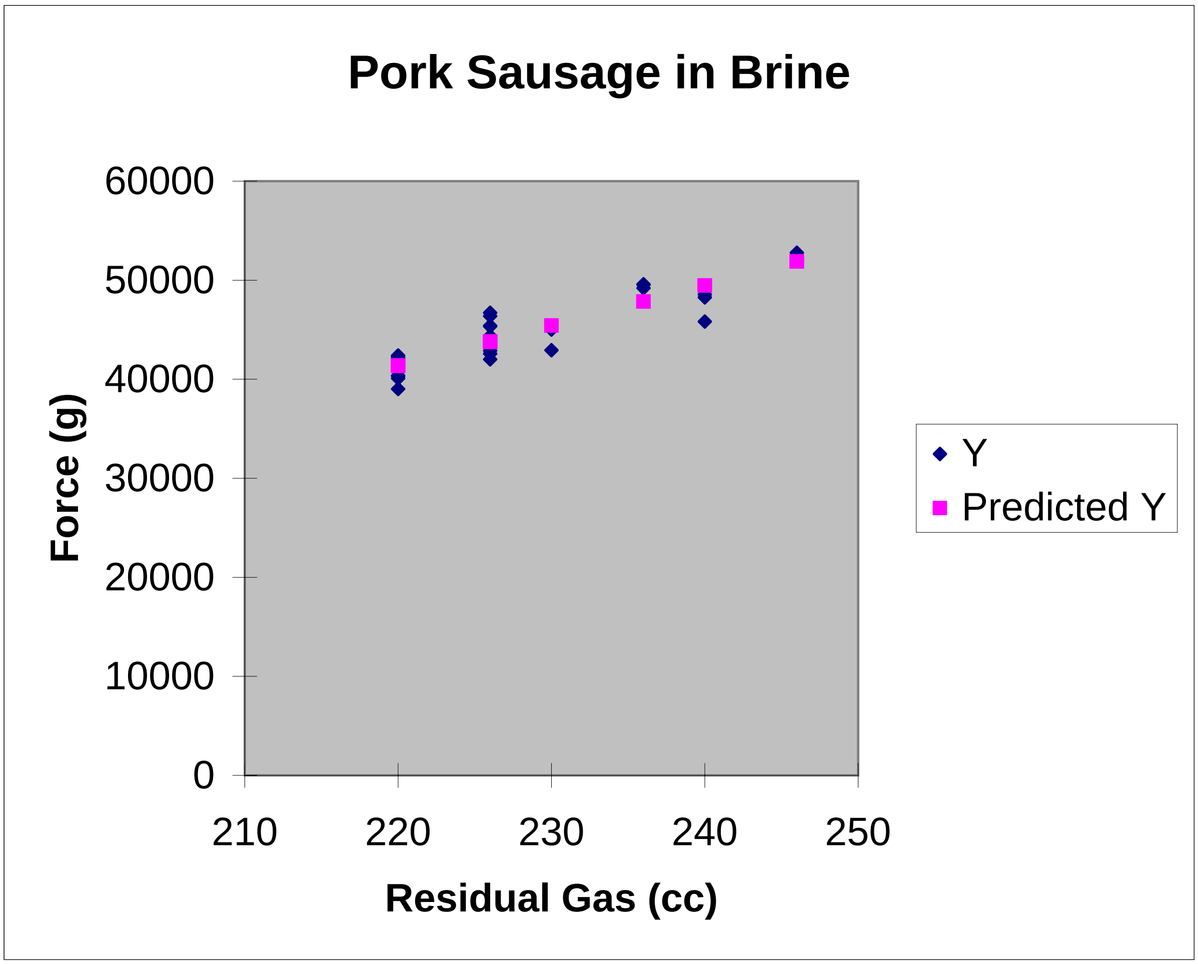
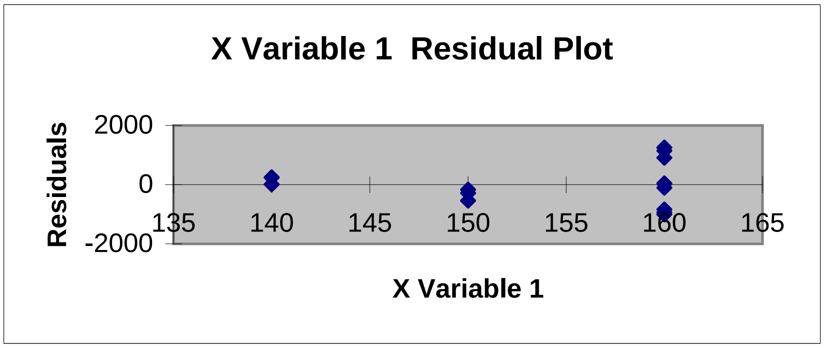
-5000
215
220
225
230
235
240
245
250
X Variable 1


Pork Sausage in Brine
Force (g)
60000
50000
40000
30000
20000
10000
0
210
220
230
240
250
Residual Gas (cc)
Y
Predicted Y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Residuals
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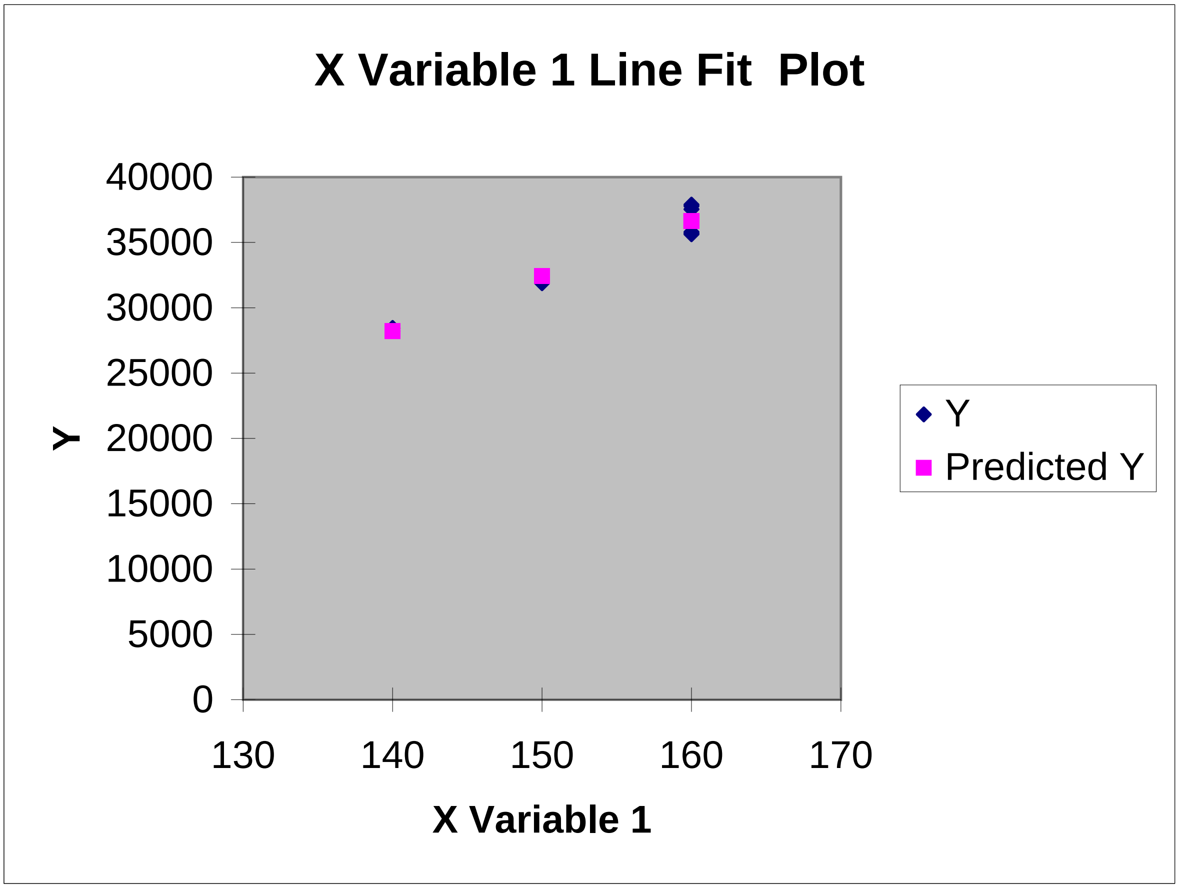
0
-2000
135
140
145
150
155
160
165
X Variable 1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Y
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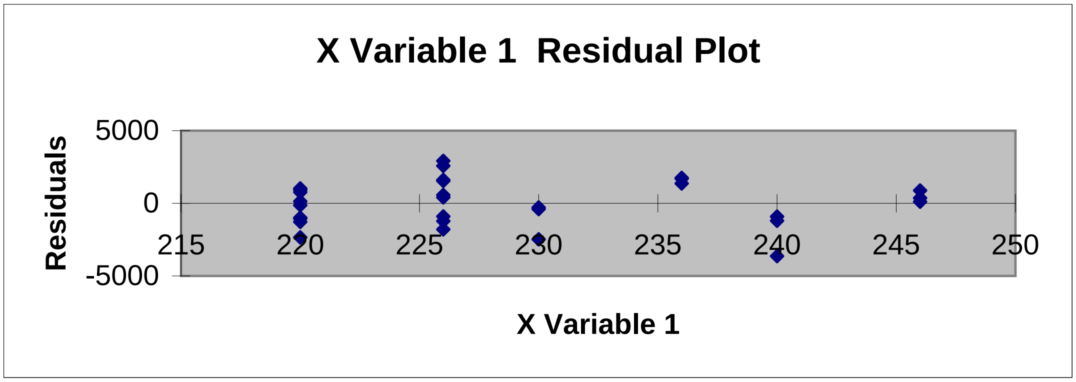
35000
30000
25000
20000
15000
10000
5000
0
130
140
150
160
170
X Variable 1
Y
Predicted Y


X Variable 1 Residual Plot
Residuals
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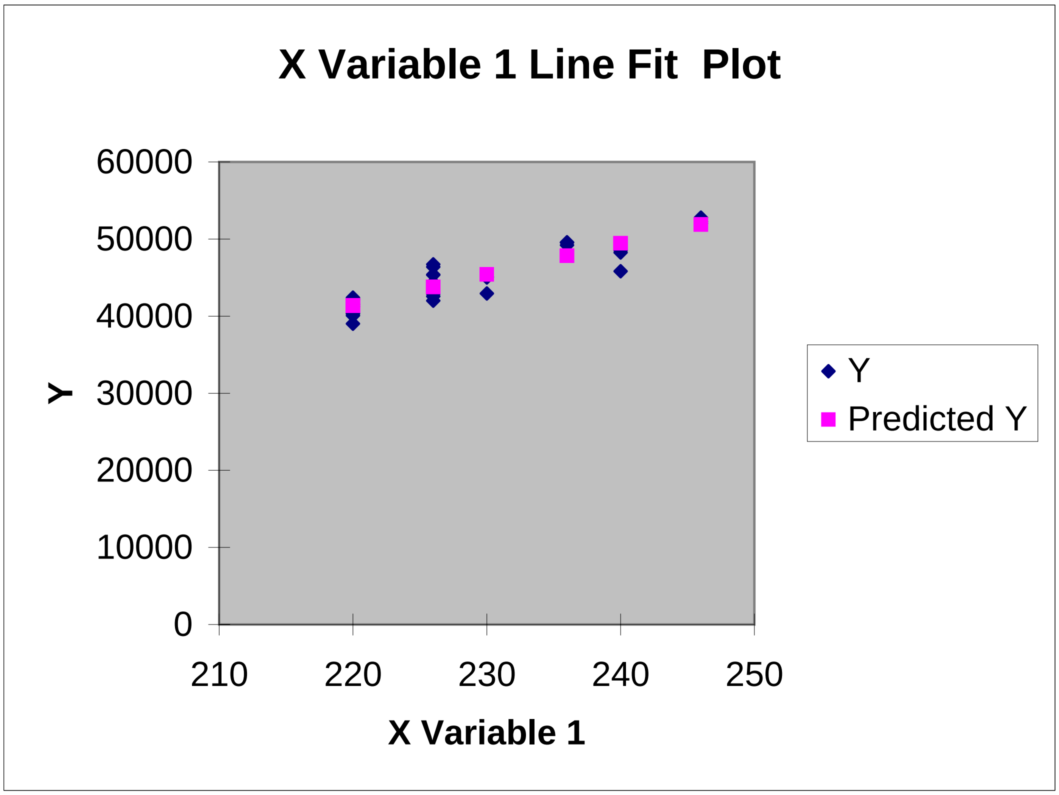
0
-5000
215
220
225
230
235
240
245
250
X Variable 1


X Variable 1 Line Fit Plot
Y
60000
50000
40000
30000
20000
10000
0
210
220
230
240
250
X Variable 1
Y
Predicted Y

Gross Forc	Res Gas	gross wt	Vacuum	offsetwt				
28212.65	140	2747	844.2977	747	28206	28206	11.21878	0.000236
28448.71	140	2747	843.9704	747	28206	28206		0.008531
28439.67	140	2747	843.5051	747	28206	28206		0.008216
31878.28	150	2747	843.5193	747	32422	32422		-0.017056
32247.52	150	2747	843.4779	747	32422	32422		-0.005411
32132.28	150	2747	844.7516	747	32422	32422		-0.009017
35694.3	160	2747	843.3314	747	36638	36638		-0.026438
35796.89	160	2747	843.6105	747	36638	36638		-0.023497
35626.76	160	2747	843.7227	747	36638	36638		-0.028384
36675.14	160	2757	843.8223	757	36638	36525.81		0.001013
36528.12	160	2757	843.1975	757	36638	36525.81		-0.003008
36663.4	160	2757	843.7436	757	36638	36525.81		0.000693
37780.54	160	2767	843.7771	767	36638	36413.62		0.030241
37888.56	160	2767	844.0629	767	36638	36413.62		0.033006
37539.02	160	2767	844.1005	767	36638	36413.62		0.024002
40305.92	220	2759	789.8987	759				
40380.75	220	2759	790.5255	759				
40084.64	220	2759	789.7761	759				
41498.25	220	2769	790.8276	769				
41230.96	220	2769	790.5569	769				
39023.51	220	2769	778.66	769				
42395.29	220	2779	790.1268	779				
42137.75	220	2779	790.5272	779				
42296.11	220	2779	789.9518	779				
45127.98	230	2779	789.879	779				
45012.94	230	2779	790.0807	779				
42933.96	230	2779	778.8708	779				
48552.56	240	2779	790.0531	779				
48263.51	240	2779	790.9394	779				
45823.11	240	2779	778.5759	779				
42005	226	2749	778.8177	749				
44365.28	226	2749	790.4285	749				
44201.02	226	2749	790.2858	749				
42571.6	226	2759	778.1524	759				
45338.8	226	2759	790.8904	759				
45398.38	226	2759	790.3732	759				
46375.74	226	2769	790.0267	769				
46709.83	226	2769	790.4323	769				
42887.57	226	2769	778.3105	769				
49537.89	236	2769	790.8653	769				
49591.63	236	2769	790.2933	769				
49209	236	2769	789.8029	769				
52776.15	246	2769	792.8015	769				
52002.61	246	2769	790.8804	769				
52258.43	246	2769	790.9297	769				

		calc gas	%diff	
0.000236	1.29E-16	140.0158	-0.01%	0.01%
0.008531	1.28E-16	140.5757	-0.41%	0.41%
0.008216	1.27E-16	140.5542	-0.40%	0.40%
-0.017056	1.14E-16	148.7103	0.86%	0.86%
-0.005411	1.13E-16	149.5862	0.28%	0.28%
-0.009017	1.14E-16	149.3128	0.46%	0.46%
-0.026438	0	157.7616	1.40%	1.40%
-0.023497	0	158.005	1.25%	1.25%
-0.028384	0	157.6014	1.50%	1.50%
0.004072	-0.003059	160.0881	-0.06%	0.06%
6.32E-05	-0.003071	159.7394	0.16%	0.16%
0.003753	-0.00306	160.0603	-0.04%	0.04%
0.03618	-0.005939	162.71	-1.69%	1.69%
0.038928	-0.005922	162.9662	-1.85%	1.85%
0.029979	-0.005977	162.1372	-1.34%	1.34%
		217.3777	-1.19%	1.19%
		217.5626	-1.11%	1.11%
		216.831	-1.44%	1.44%
		220.3237	0.15%	0.15%
		219.6632	-0.15%	0.15%
		214.2092	-2.63%	2.63%
		222.54	1.15%	1.15%
		221.9037	0.87%	0.87%
		222.295	1.04%	1.04%
		229.2918	-0.31%	0.31%
		229.0076	-0.43%	0.43%
		223.8709	-2.66%	2.66%
		237.7531	-0.94%	0.94%
		237.0389	-1.23%	1.23%
		231.0093	-3.75%	3.75%
		221.5757	-1.96%	1.96%
		227.4074	0.62%	0.62%
		227.0015	0.44%	0.44%
		222.9756	-1.34%	1.34%
		229.8127	1.69%	1.69%
		229.9599	1.75%	1.75%
		232.3747	2.82%	2.82%
		233.2002	3.19%	3.19%
		223.7563	-0.99%	0.99%
		240.1876	1.77%	1.77%
		240.3204	1.83%	1.83%
		239.375	1.43%	1.43%
		248.1885	0.89%	0.89%
		246.2773	0.11%	0.11%
		246.9094	0.37%	0.37%
			-3.75%	1.15%
			3.19%	

Appendix 4.2.2 Precision Automation Evaluation Experimental Data - Turkey

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.986715
R Square	0.973607
Adjusted R	0.972993
Standard E	1025.92
Observatio	45

ANOVA

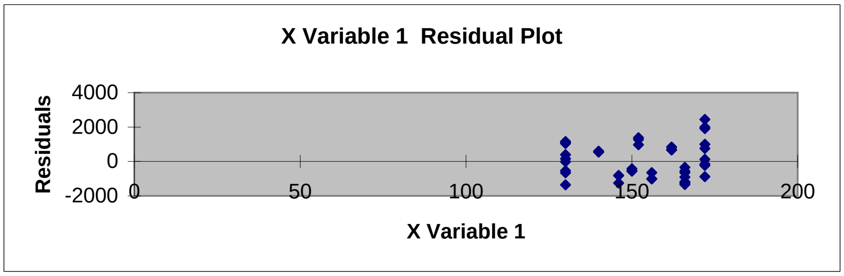
	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	1	1.67E+09	1.67E+09	1586.2	1.41E-35
Residual	43	45258050	1052513		
Total	44	1.71E+09			

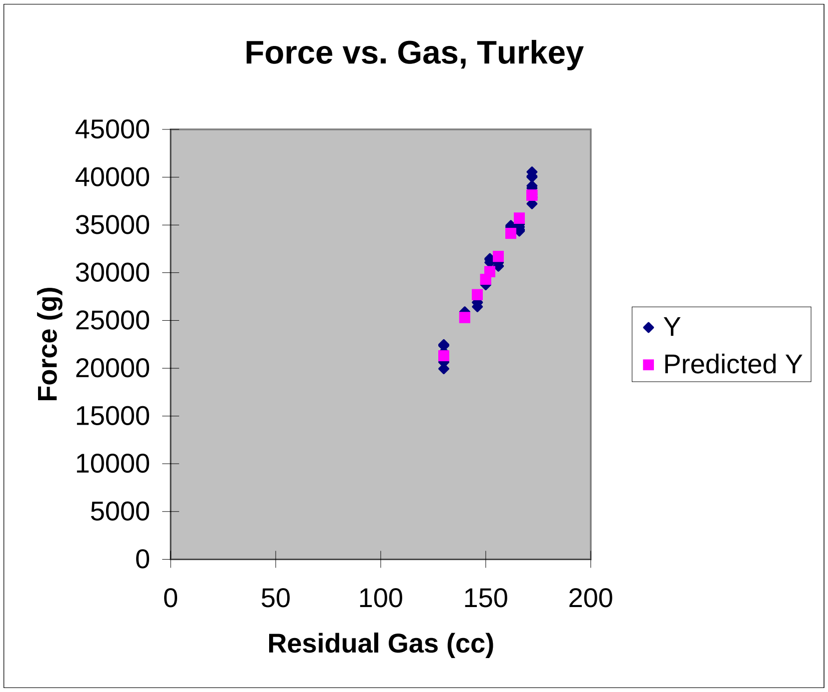
	Coefficients	*andard Erro*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Ipper 95.0%*
Intercept	-30681.15	1553.811	-19.74575	3.48E-23	-33814.7	-27547.59	-33814.7	-27547.59
X Variable	399.8918	10.04069	39.82713	1.41E-35	379.6428	420.1407	379.6428	420.1407

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*	*idard Residuals*
1	27703.05	-812.7823	-0.801406
2	27703.05	-818.3819	-0.806927
3	27703.05	-1255.196	-1.237628
4	31701.97	-1013.864	-0.999673
5	31701.97	-645.5341	-0.636499
6	31701.97	-1016.225	-1.002002
7	35700.89	-1192.137	-1.175452
8	35700.89	-1339.094	-1.320352
9	35700.89	-1241.899	-1.224517
10	35700.89	-344.0827	-0.339267
11	35700.89	-648.7194	-0.63964
12	35700.89	-1189.778	-1.173125
13	35700.89	-563.1647	-0.555282
14	35700.89	-913.0749	-0.900295
15	35700.89	-1283.766	-1.265798
16	30102.4	1277.394	1.259515
17	30102.4	974.6795	0.961037
18	30102.4	1378.535	1.35924
19	34101.32	662.0352	0.652769
20	34101.32	840.5664	0.828801
21	34101.32	706.0274	0.696145
22	38100.24	-225.8786	-0.222717
23	38100.24	-881.238	-0.868904
24	38100.24	-155.6755	-0.153497
25	38100.24	758.4026	0.747788
26	38100.24	121.2307	0.119534
27	38100.24	995.7386	0.981802
28	38100.24	2440.18	2.406026
29	38100.24	1912.481	1.885712
30	38100.24	1996.414	1.968471
31	21304.78	-1360.902	-1.341854
32	21304.78	-662.3653	-0.653094
33	21304.78	-539.1603	-0.531614
34	21304.78	157.2538	0.155053
35	21304.78	390.6737	0.385206
36	21304.78	-16.04894	-0.015824
37	21304.78	1049.875	1.03518
38	21304.78	1113.705	1.098117
39	21304.78	1162.791	1.146516
40	25303.7	596.4141	0.588066
41	25303.7	564.0274	0.556133
42	25303.7	544.0567	0.536442
43	29302.62	-538.1423	-0.53061
44	29302.62	-561.3201	-0.553464
45	29302.62	-424.0486	-0.418113

Appendix 4.2.2 Precision Automation Evaluation Experimental Data - Turkey





Gross Forc	Res Gas	gross wt	Vacuum	calc gas	% diff	
26890.27	146	3131	844.316	143.9675	1.39%	1.39%
26884.67	146	3131	844.0123	143.9535	1.40%	1.40%
26447.86	146	3131	843.9725	142.8612	2.15%	2.15%
30688.11	156	3131	844.4596	153.4647	1.63%	1.63%
31056.44	156	3131	844.137	154.3857	1.03%	1.03%
30685.74	156	3131	844.4081	153.4587	1.63%	1.63%
34508.75	166	3131	843.8955	163.0189	1.80%	1.80%
34361.79	166	3131	843.5356	162.6514	2.02%	2.02%
34458.99	166	3131	844.0323	162.8944	1.87%	1.87%
35356.8	166	3141	843.3394	165.1396	0.52%	0.52%
35052.17	166	3141	844.1604	164.3778	0.98%	0.98%
34511.11	166	3141	844.3701	163.0248	1.79%	1.79%
35137.72	166	3151	843.6503	164.5917	0.85%	0.85%
34787.81	166	3151	843.4637	163.7167	1.38%	1.38%
34417.12	166	3151	843.8432	162.7897	1.93%	1.93%
31379.8	152	2947	844.3027	155.1944	-2.10%	2.10%
31077.08	152	2947	843.8846	154.4374	-1.60%	1.60%
31480.94	152	2947	843.688	155.4473	-2.27%	2.27%
34763.36	162	2947	844.0917	163.6555	-1.02%	1.02%
34941.89	162	2947	844.3027	164.102	-1.30%	1.30%
34807.35	162	2947	843.9667	163.7655	-1.09%	1.09%
37874.36	172	2947	844.6127	171.4352	0.33%	0.33%
37219	172	2947	843.4005	169.7963	1.28%	1.28%
37944.56	172	2947	843.734	171.6107	0.23%	0.23%
38858.64	172	2957	843.7762	173.8965	-1.10%	1.10%
38221.47	172	2957	843.9742	172.3032	-0.18%	0.18%
39095.98	172	2957	844.3495	174.49	-1.45%	1.45%
40540.42	172	2967	843.7315	178.1021	-3.55%	3.55%
40012.72	172	2967	843.9323	176.7825	-2.78%	2.78%
40096.65	172	2967	843.2628	176.9924	-2.90%	2.90%
19943.88	130	2980	844.3416	126.5968	2.62%	2.62%
20642.42	130	2980	843.8143	128.3436	1.27%	1.27%
20765.62	130	2980	844.0076	128.6517	1.04%	1.04%
21462.04	130	2990	843.7578	130.3932	-0.30%	0.30%
21695.46	130	2990	843.9022	130.9769	-0.75%	0.75%
21288.73	130	2990	843.4603	129.9599	0.03%	0.03%
22354.66	130	3000	844.1859	132.6254	-2.02%	2.02%
22418.49	130	3000	844.378	132.785	-2.14%	2.14%
22467.57	130	3000	843.6863	132.9078	-2.24%	2.24%
25900.12	140	3000	844.2889	141.4914	-1.07%	1.07%
25867.73	140	3000	844.2872	141.4105	-1.01%	1.01%
25847.76	140	3000	843.8604	141.3605	-0.97%	0.97%
28764.48	150	3000	844.3968	148.6543	0.90%	0.90%
28741.3	150	3000	844.1788	148.5963	0.94%	0.94%
28878.57	150	3000	844.3633	148.9396	0.71%	0.71%
					0.00%	1.41%
					-3.55%	
					2.62%	

Beef Raw data

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Pork raw data

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USONPOR1

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USONTURK

Turkey raw data

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Validation Protocol for the Non Destructive Residual Gas Tester rev. 1.3 Final

The ND-RG tester can be used in two areas of the production process of polymeric trays:

1. Pre-retort Residual Gas
2. Post Retort Residual Gas (finished product)

Validation testing in both areas should be similar, because of the interaction between product temperature, gas expansion and vapor pressure of the liquid, the area that yields the most consistent product temperature will probably yield the most accurate data until adequate information has been collected on how to offset and adjust for product temperature variations. Finished product lots should be at a relative constant temperature (warehouse temperature) and thus the preferred area to start validation tests.

Validation Test Protocol:
Submit proposed protocol to DSCP, Natick and USDA to inform them of the intent to substitute the destructive residual gas test with a non-destructive method.

Take the normal sample set of trays from the finished product lot.
Record in database:

1) Product name
2) Lot Number
3) Net Weight
4) Tray Temperature (insulated contact thermocouple or laser scanner)

Load Tray in the ND-RG tester
Run standard program and record predicted residual gas

Repeat test two more times to yield a total of three estimated values for residual gas.
Perform a destructive residual gas test on the sample and record residual gas.

Repeat above for a total of 25 trays per product. Communicate data back to Jeff Canavan on a weekly basis. If changes in test methodology are made, data from previous tests will be re-evaluated to verify results.

After validation work of a finished product (25 trays) has been completed, submit data to DSCP, Natick and USDA to petition for a test method substitution for that specific product. Based on their analysis and feedback adjust protocol as needed.

Once post-process testing of 10 products has been completed, work will begin on pre-retort residual gas testing. The same protocol is recommended with the exception of temperature data collection procedure. The tray should be inverted or tilted on an edge to expose the lidstock to the product for 3+ minutes. The temperature of the lower section of the lidstock should be recorded by an insulated contact thermocouple or laser temperature device. Changes to the test vacuum set points and protocol formulas may be required for different temperatures. Interface changes may include a user input of temperature. Communicate data back to Jeff Canavan.

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ISO 9001

Registered Company

August 4, 2005

Rutgers, The State University of New Jersey
CAFT/FMTF
120 New England Ave
Piscataway, NJ 08854

Attn: Jeff Canavan

The following proposal 05-03932 is in response to a request for a design and implementation proposal for the **Residual Gas Tray Tester** project.

This proposal has been prepared after a careful review of all the project requirements. An approach has been developed utilizing extensive machine and control system integration experience. As a result, we believe that this approach will lead to a successful project that will be on target, on time and on budget.

Please keep in mind that this document includes information that has been developed using technical skills, methodologies and preliminary engineering that are the property of Precision Automation. As a result, Precision Automation would expect the customer to treat the content of this document as confidential information just as the customer would expect Precision Automation to treat as confidential information, any process information provided by the customer.

Thank you for this opportunity to provide this proposal. We are looking forward to meeting with you to review this proposal in detail and providing our services on this and future projects.

Very truly yours,

Jack Tarman

Jack Tarman

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1. File
2. JET File

Basis of Proposal:

The following information has either been provided to Precision Automation or is the result of Precision Automation's development of an approach to provide an automation solution within the declared needs and constraints. All of the following information forms the basis of this proposal:

Customer Requirements:

I. General Requirements:
   A. Provide an Audit Tester in a 1 up configuration for non-destruct testing of trays for excess residual gas with flexibility for use in an R&D environment.
   B. Refer to Precision Automation proposal 04-03498 dated 9/14/04 and provide proposal for additional rental through 11/05 and modify software to revise the test process.
      1. Phase 2 has been completed and consisted of a new test algorithm that included functions as developed by Rutgers. The machine has been leased to Rutgers for a 3 mo. Period of time for testing at Rutgers and a demonstration of the machine and test process to potential users.
      2. Phase 3 and 4 will be modified in this proposal.

II. Specifications:
   A. Residual gas tray testing:
      1. Tray Description: 12.5"x10.25"x1.75" with top membrane seal.
      2. Contents: Retorted Food Products.
      3. Residual Gas: Air, 0-250 cc. Reject approx. 150-200 cc.
   B. Previous documents:
      1. Precision Automation proposal 02-02278 dated 6/20/02 for a residual gas test machine with MRE software enhancements.
      2. Precision Automation proposal 03-02730 dated 04/25/03 to incorporate modifications to Precision's 1 up tester that will enable preliminary testing of the trays.
      3. Precision Automation proposal 03-03498 dated 09/14/04 to incorporate modifications to Precision's 1 up tester that will enable preliminary testing of the trays, machine rental and machine purchase.

Current Tray Test Process:

I. Destruct test: Product is destroyed during the testing.

II. Filled, sealed tray is submersed under water and under a filled inverted funnel. Package is opened and gases are expelled, rise into the inverted funnel, are collected and measured. The tray's product is then flushed down the sink and garbage disposal.

III. Disadvantages:

A. Destruct process creates waste and is costly.
B. Process is time consuming not just in set-up and testing but also in manual recording of data, which can lead to inaccuracies.
C. Process is messy and requires considerable cleanup.

Proposed Scope:

The following tasks and deliverables for this project are expected to be provided by Precision Automation's project execution process:

Initial Rental and Design Phase (Completed):

<u>This project phase has been completed</u>. The "Standard Audit Tester – 1 Up R&D Version required modifications for the tray specified in the requirements section. After the machine modifications were completed machine time and technical assistance was provided to Rutgers to run preliminary tests, collect data, analyze data and develop reports. Test algorithms as developed by Rutgers during Phase 1 have been incorporated and the machine has been leased to Rutgers for a 3 mo. Period of time for testing at Rutgers for a demonstration of the machine and test process to potential users.

Software Modifications & Additional Machine Rental:

I. This project phase will provide additional software modifications to the "Standard Audit Tester – 1 Up R&D Version.
   A. Gas Release from Product – Phase 1.
   B. Head Space Test – Phase 2 & 3:
      1. Phase 2 – Run test without insert.
      2. Phase 3 – Run test with insert.
II. The tested machine will be provided to the Rutgers facility for additional testing and demonstration on a 5-month lease.
III. The approach to implementation will be software modifications at the Precision Automation facility and then downloading and testing of revised software at Rutgers by Rutgers.

Machine Purchases:

As a result of the successful completion of the testing and demonstration, this project phase will provide for the purchase of the machine previously leased with credits for a portion of the lease payments. This proposal also includes pricing for a 2nd and 3rd third tray test machine identical to the 1st machine.

Commercial:

Pricing – Initial Rental and Design Phase: (Completed)

Pricing for project scope as outlined above:

I.	Software development, test, debug (80 hr allowance)	$ 6,800.
II.	3 mo. Machine rental @ $2,100/mo.	$ 6,300.
III.	**Total Price – Rental and Design (Completed)**	**$ 13,100.**

Pricing – Software Modification & Additional Rental:

Pricing for project scope as outlined above:

I.	Software modifications (20 Hr)	$ 1,700.
II.	5 mo. Machine rental @ $2,00/mo.	$ 10,000.
III.	**Total Price – Software Modification & Addl Rental**	**$ 11,700.**

Pricing – 1st Tray Test Machine Purchase:

Pricing for project scope as outlined above:

I.	Machine purchase	$ 49,250.
II.	Credit-s/w development	($ 6,800.)
III.	Credit-1/2 initial rental	($ 3,150.)
IV.	Credit-1/2 additional rental	($ 5,000.)
V.	**Total Price – 1st Tray Test Machine Purchase**	**$ 34,300.**

Pricing – 2nd Tray Test Machine Purchase:

Pricing for project scope as outlined above:

I.	Machine purchase	$ 45,650.
II.	**Total Price – Additional Tray Test Machine Purchase**	**$ 45,650.**

Pricing – 3rd Tray Test Machine Purchase (Order with 2nd Machine):

Pricing for project scope as outlined above:

I.	Machine purchase	$ 42,450.
II.	**Total Price – Additional Tray Test Machine Purchase**	**$ 42,450.**

Notes:

Prices quoted are FOB Precision Automation, Cherry Hill, NJ.